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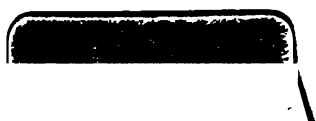
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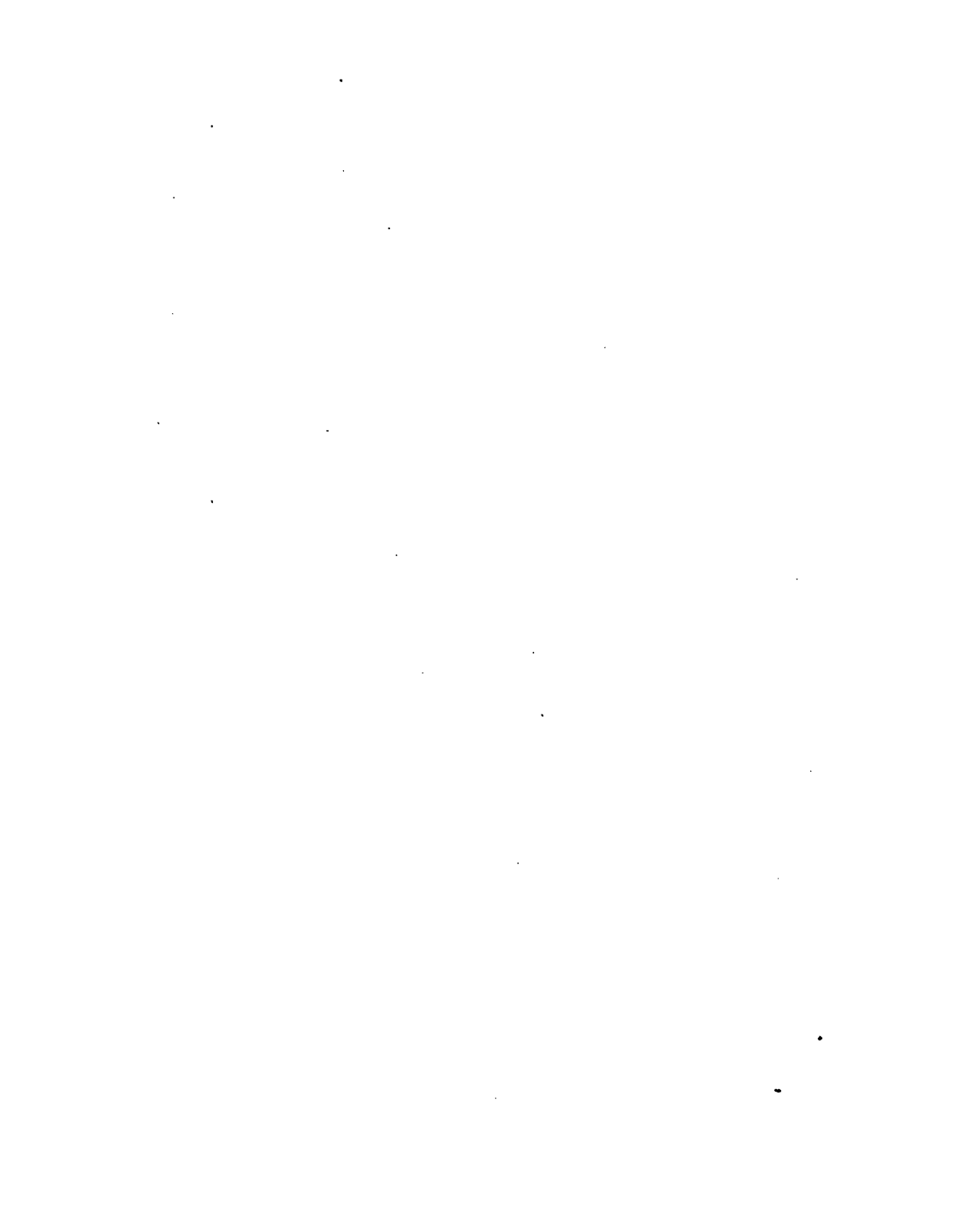
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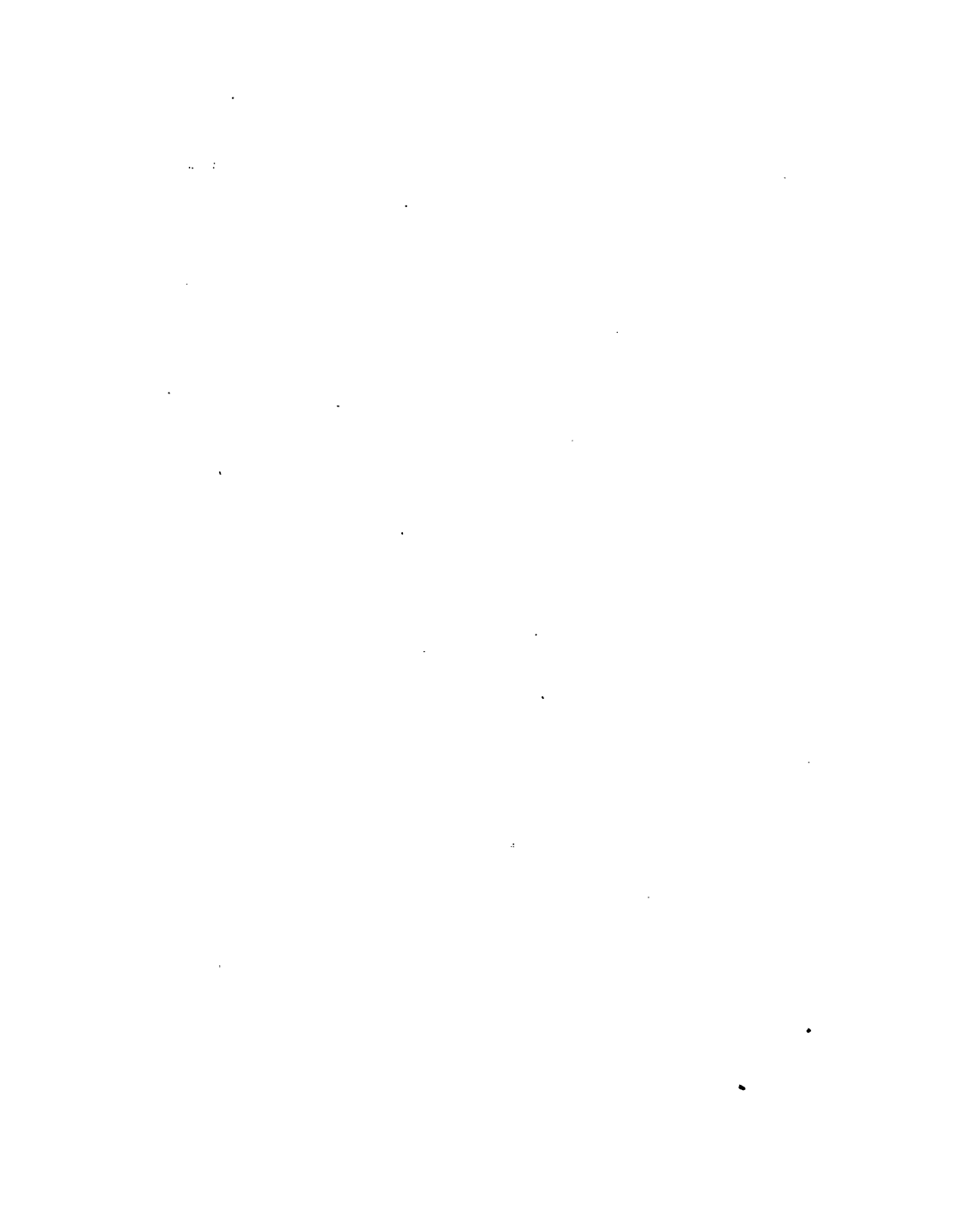
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INORGANIC CHEMISTRY,  
FOR  
SCIENCE CLASSES.

BY  
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## P R E F A C E .

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THIS work has been provided for the use of beginners in the study of Chemistry more especially for students of Science Classes. It has therefore been made an especial object to avoid technicalities as far as possible, and to afford a plain and brief description of the preparation and properties of the elementary bodies, and their principal compounds. A complete enumeration of these bodies would have occupied much space, and might distract the attention of the learner from those properties with which it is important he should first become acquainted ; nevertheless, the present volume exhibits a comprehensive view of the latest improvements and discoveries of modern chemical science.

The author is not acquainted with any elementary work in which the new system of molecular equivalents and systematic notation has been adopted, and where the various Rules are

the data for calculating the equivalent by weight of the compound, but also gives him the proportion by volume in which the elements are united. The formula in common use,  $\text{HO}$ , does not represent the proportion by volume in which the elements exist.

3rd. The chemical equivalents usually adopted do not represent uniform combining quantities. "In the first place, let us observe that the composition of the poly acid bases, such as alumina and ferric oxide, has almost always been expressed by molecular formula, and not by equivalent formula. It was known that one molecule of alumina would saturate three molecules of sulphuric acid, and this quantity was wrongly termed an equivalent of alumina. The true equivalent of alumina—that is to say, the quantity of alumina which corresponds to one molecule of potash or oxide of silver—is the quantity of alumina which contains an equivalent of oxygen. It is this quantity which saturates an equivalent of sulphuric acid. The general formula used,  $\text{Al}_2\text{O}_3, 3 \text{SO}_3$ , did not express an equivalent of sulphate of alumina, but a molecule of sulphate of alumina." . . . "It is seen from the above that after having pointed out the difference between atoms and equivalents, the progress of science leads to the separation of the idea of molecule from that of equivalent of a compound body."\*

*An atom* is the smallest quantity of an element, indivisible by chemical means, which can exist in a compound body.

*A molecule* is the smallest quantity of an element—radical, acid, base, salt, or other compound—which is supposed to exist in the free state.

"Molecules, in fact, are not always equivalent among each other. One equivalent of phosphoric acid is not equivalent to one molecule of acetic acid, and one molecule of alumina is not equivalent to one equivalent of oxide of silver."\*

One atomic equivalent of citric acid will neutralise three atomic equivalents of sodium, and one atomic equivalent of oxide of bismuth require three atomic equivalents of nitric acid to form ternitrate of bismuth.

4th. The recent researches in organic chemistry of our most distinguished chemists tend to establish the molecular

\* A. Wurtz, *Chemical News*, vol. 11, page 110.

equivalents of carbon as 12 and oxygen as 16. The limits of this work will not admit of any lengthy arguments in favour of the new notation; let it suffice that, after examining the question of specific heat, isomorphism, &c., and the principal arguments *pro* and *con*, the author considers that the weight of evidence is in favour of the new molecular equivalents.

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*Chemical Affinity* is the affinity of one substance for another. After combination the compound usually possesses new characters and properties. The following are a few examples :—

Ex. 1. The metal sodium is a powerful alkaline base; when introduced into a jar of chlorine gas, the affinity of the sodium and chlorine cause them to enter into combination forming chloride of sodium, common salt.

Ex. 2. When a mixture of oxygen and hydrogen are caused to unite (by an electric spark), an explosion takes place, the gases disappear, and water is formed by the chemical affinity of oxygen for hydrogen.

Ex. 3. If to a solution of chloride of barium sulphuric acid be added, the affinity of sulphuric acid for barium being greater than the affinity of chlorine for that base, sulphate of barium is formed, and chlorine in combination with hydrogen (HCl) remains in solution.

Ex. 4. When water is added to quicklime (oxide of calcium), great heat is generated from the chemical union of the oxide of calcium with water forming hydrated oxide of calcium.

Ex. 5. If a piece of potassium be thrown on water, the affinity of the potassium for the oxygen of the water causes its decomposition, oxide of potassium is formed, and hydrogen set free. The heat generated is sufficient to spontaneously ignite the hydrogen gas.

Ex. 6. When a few grains of iodine are brought in contact with phosphorus, the affinity which exists between these elements causes them to combine with the spontaneous combustion of a portion of the phosphorus.

*Equivalents* are the proportions by weight or volume in which one element or compound unites with another to form

a definite chemical salt or compound. The following are a few examples :—

EQUIVALENT BY WEIGHT.

Ex. 1. The equivalent of hydrogen is 1, and that of chlorine is 35·46. These elements combine forming hydrochloric acid gas, the equivalent of which is 36·46.

Ex. 2. The equivalent of sodium is 23, and that of chlorine 35·46. These elements combine forming chloride of sodium, equivalent 58·46.

Ex. 3. The equivalent of nitrate of silver is 169·97, and that of chloride of sodium 58·46. If these salts are dissolved (in equivalent quantities) in water and mixed, one equivalent of chloride of silver, 143·43, and one equivalent of nitrate of sodium, 85·00 are formed.

Ex. 4. The equivalent of hydrochloric acid is 36·46, and that of hydrate of potassium is 56·11. If these compounds be mixed, one equivalent of chloride of potassium, 74·57, and one equivalent of water, 18·00 are formed.

Ex. 5. One equivalent of zinc, 65·06, when dissolved in one equivalent of sulphuric acid, 98·00, forms one equivalent of sulphate of zinc, 161·06, and two equivalents of hydrogen, 2·00 are evolved.

• EQUIVALENT BY VOLUME.

Ex. 1. The volume of hydrogen is 1, and that of oxygen is also 1. Water,  $H_2O$ , is formed when two volumes of hydrogen are united with one volume of oxygen.

Ex. 2. The volume of nitrogen is 1, and that of hydrogen is 1. Ammonia,  $NH_3$ , is formed when one volume of nitrogen is exploded with three volumes of hydrogen.

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*Elements or simple substances* are forms of matter that we are unable to resolve into any simpler condition. Thus, oxygen, hydrogen, sulphur, &c., are termed elements. Water or air are not elements, being resolvable, the former (water) into oxygen and hydrogen gases; the latter (air) into oxygen, nitrogen, gases, &c. The number of elementary bodies at present recognised are 65, of which about 50 are metals, the rest are termed the non-metallic or metalloid elements. Arsenic and Tellurium, though possessing the properties of metals, are yet intimately connected with the metalloids.

*Acid.*—Solutions of acids and all acid substances have the property of changing (most) vegetable blue colouring matters red. Example: Blue litmus papers are used extensively in the laboratory for the purpose of detecting the presence of acids, which immediately turn the blue colour red. All acids unite with bases to form compounds named salts.

*Alkali.*—Solutions of alkalis and all alkaline substances possess the property of changing red litmus blue, and yellow turmeric of a reddish brown colour. Red litmus papers and yellow tumeric test papers are employed for the detection of alkalis in solution. All alkalis unite with acids to form salts, which are usually neutral.

*Base.*—Bases, alkaline or otherwise, unite with acids to form neutral, acid, or alkaline salts.

#### EXAMPLES OF SALTS.

A neutral salt, sulphate of potassium  $K_2SO_4$ , is formed when one equivalent of sulphuric acid,  $H_2SO_4$ , unites with one equivalent of oxide of potassium,  $K_2O$ .

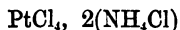
An acid salt, bi-sulphate of potassium  $K, H, SO_4$  is formed when two equivalents of sulphuric acid,  $H_2SO_4$ , unite with one equivalent of oxide of potassium,  $K_2O$ ; two equivalents of the acid sulphate are formed.

An alkaline salt, carbonate of potassium,  $K_2CO_3$ , is formed when one equivalent of a feeble acid, carbonic acid  $CO_2$ , unites with one equivalent of oxide of potassium.

*Rational Formulæ* express the arrangement or grouping of elements according to their supposed affinities for each other, thus: Potash alum, a crystalline double salt, is considered to be sulphate of aluminium and sulphate of potassium in combination with twenty-four equivalents of water of crystallisation. The rational formula is therefore



Chloride of platinum and ammonium, a crystalline double salt, is considered to be a chloride of platinum in combination with chloride of ammonium. The rational formula is therefore



*Empirical Formulæ* simply expresses the number of atoms of each element in a compound without conveying any idea

of their arrangement, thus : The empirical formula of potash alum might be written



And chloride of platinum and ammonium

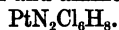


Table of Elementary Substances, with their Symbols, and  
New and Old Equivalents.

NAME.	SYMBOL.	New Equiva- lent.	Old Equiva- lent.	NAME.	SYMBOL.	New Equiva- lent.	Old Equiva- lent.
Aluminium ..	Al	27.26	13.63	Molybdenum ..	Mo	96.00	48.00
Antimony ....	Sb	122.00	122.00	Nickel .....	Ni	59.00	29.50
Arsenic .....	As	75.00	75.00	Niobium .....	Nb	..	47.00
Barium .....	Ba	137.18	68.59	Nitrogen .....	N	14.00	14.00
Beryllium ....	Be	14.00	7.00	Norium .....	No	..	..
Bismuth .....	Bi	210.00	210.00	Osmium .....	Os	199.20	99.60
Boron .....	B	11.04	11.04	Oxygen .....	O	16.00	8.00
Bromine .....	Br	79.97	79.97	Palladium ....	Pd	106.66	53.30
Cadmium .....	Cd	112.00	56.00	Phosphorus ..	P	31.00	31.00
Cæsium .....	Cs	133.00	133.00	Platinum .....	Pt	197.88	98.94
Calcium .....	Ca	40.00	20.00	Potassium ....	K	39.11	39.11
Carbon .....	C	12.00	6.00	Rhodium .....	R	104.40	52.20
Cerium .....	Ce	92.00	46.00	Rubidium ....	Rb	85.40	85.40
Chlorine .....	Cl	35.46	35.46	Ruthenium ....	Ru	101.40	50.70
Chromium .....	Cr	53.50	26.75	Selenium .....	Se	79.00	39.50
Cobalt .....	Co	59.00	29.50	Silicium .....	Si	28.00	14.00
Copper .....	Cu	63.56	31.78	Silver .....	Ag	107.97	107.97
Didymium ....	Di	96.00	48.00	Sodium .....	Na	23.00	23.00
Erbium .....	E	..	..	Strontium .....	Sr	87.34	43.67
Fluorine .....	F	19.00	19.00	Sulphur .....	S	32.00	16.00
Gold .....	Au	196.67	196.67	Tantalum ....	Ta	137.60	68.80
Hydrogen .....	H	1.00	1.00	Tellurium ....	Te	128.00	64.00
Iodine .....	I	126.88	126.88	Terbium .....	Tr	..	..
Iridium .....	Ir	198.00	99.00	Thallium .....	Tl	..	204.00
Iron .....	Fe	56.00	28.00	Thorium .....	Th	231.50	59.60
Indium .....	In	71.80	35.90	Tin .....	Sn	118.00	59.00
Lanthanum ....	Ln	92.80	46.40	Titanium .....	Ti	50.00	25.00
Lead .....	Pb	207.14	103.57	Tungsten ....	W	184.00	92.00
Lithium .....	Li	6.95	6.95	Uranium .....	U	120.00	60.00
Magnesium ..	Mg	24.00	12.00	Vanadium ....	V	68.60	68.60
Manganese ....	Mn	55.14	27.57	Yttrium .....	Y	68.00	34.00
Mercury .....	Hg	200.00	100.00	Zinc .....	Zn	65.06	32.53
				Zirconium ....	Zr	89.60	44.80

## SYSTEMATIC NAMES.

COMMON NAME.	SYSTEMATIC NAME.
Aluminium, Sesquioxide of	<i>Aluminic Oxide</i>
Alumina, Acetate of	" <i>Acetate</i>
" Nitrate of	" <i>Nitrate</i>
" Sulphate of	" <i>Sulphate</i>
Ammonium, Oxide of	<i>Ammonic Oxide</i>
" Bromide of	" <i>Bromide</i>
" Chloride of	" <i>Chloride</i>
" Sulphide of	" <i>Sulphide</i>
Ammonia, Acetate of	" <i>Acetate</i>
" Nitrate of	" <i>Nitrate</i>
" Neutral Oxalate of	" <i>Oxalate</i>
" Sulphate of	" <i>Sulphate</i>
" Sesquicarbonate of	<i>Diammonic Tricarbonate</i>
" Bicarbonate of	<i>Hydro-ammonic Carbonate</i>
" Carbonate of	<i>Ammonic Carbonate</i>
Antimony, Teroxide of	* <i>Antimonic Oxide</i>
Antimonic Acid (anhydrous)	" <i>Acid (anhydride)</i>
Antimony, Tetrachloride of	" <i>Chloride</i>
Arsenious Acid (anhydrous)	<i>Arsenious Acid (anhydride)</i>
Arsenic Acid (anhydrous)	<i>Arsenic Acid (anhydride)</i>
Barium, Protoxide of	<i>Baric Oxide</i>
" Binoxide of	" <i>Peroxide</i>
" Chloride of	" <i>Chloride</i>
Baryta, Carbonate of	" <i>Carbonate</i>
" Chromate of	" <i>Chromate</i>
" Nitrate of	" <i>Nitrate</i>
" Sulphate of	" <i>Sulphate</i>
Beryllium, Oxide of	<i>Beryllic Oxide</i>
Bismuth, Teroxide of	<i>Bismuthic Oxide</i>
Bismuthic Acid (anhydrous)	" <i>Acid (anhydride)</i>
Bismuth, Tetrachloride of	" <i>Trichloride</i>
" Trinitrate of	" <i>Trinitrate</i>
Cadmium, Oxide of	<i>Cadmic Oxide</i>
" Bromide of	" <i>Bromide</i>
" Carbonate of	" <i>Carbonate</i>
" Nitrate of	" <i>Nitrate</i>
" Sulphate of	" <i>Sulphate</i>
" Sulphide of	" <i>Sulphide</i>
Cæsium, Oxide of	<i>Cæsic Oxide</i>
Calcium, Oxide of	<i>Calcic Oxide</i>
" Chloride of	" <i>Chloride</i>
" Iodide of	" <i>Iodide</i>
" Fluoride of	" <i>Fluoride</i>
" Phosphide of	" <i>Phosphide</i>
" Sulphide of	" <i>Sulphide</i>



COMMON NAME.	SYSTEMATIC NAME.
Cerium, Oxide of	<i>Ceric Oxide</i>
Chromium, Sesquioxide of	<i>Chromic Oxide</i>
Chromic Acid (anhydrous)	" <i>Acid (anhydride)</i>
Chromium, Sesquichloride of	" <i>Chloride</i>
" Sesquisulphate of	" <i>Sulphate</i>
Cobalt, Protoxide of	<i>Cobaltic Oxide</i>
" Sesquioxide of	" <i>Peroxide</i>
" Chloride of	" <i>Chloride</i>
" Nitrate of	" <i>Nitrate</i>
" Sulphate of	" <i>Sulphate</i>
Copper, Suboxide of	<i>Cuprous Oxide</i>
" Protoxide of	<i>Cupric Oxide</i>
" Acetate of	" <i>Acetate</i>
" Chloride of	" <i>Chloride</i>
" Carbonate of	" <i>Carbonate</i>
" Subchloride of	<i>Cuprous Chloride</i>
" Nitrate of	<i>Cupric Nitrate</i>
" Sulphate of	" <i>Sulphate</i>
" Sulphide of	" <i>Sulphide</i>
Gold, Protoxide of	<i>Aurous Oxide</i>
" Teroxide of	<i>Auric Oxide</i>
" Protochloride of	<i>Aurous Chloride</i>
" Terchloride of	<i>Auric Chloride</i>
Iron, Protoxide of	<i>Ferrous Oxide</i>
" Sesquioxide of	<i>Ferric Oxide</i>
Ferric Acid	<i>Ferric Acid</i>
Iron, Proto Acetate of	<i>Ferrous Acetate</i>
" " Chloride of	" <i>Chloride</i>
" " Nitrate of	" <i>Nitrate</i>
" " Phosphate of (tribasic)	<i>Triferrous Phosphate</i>
" " Sulphate of	<i>Ferrous Sulphate</i>
" " Sulphide of	" <i>Sulphide</i>
" Per Acetate of	<i>Ferric Acetate</i>
" " Chloride of	" <i>Chloride</i>
" " Nitrate of	" <i>Nitrate</i>
" " Phosphate of (tribasic)	<i>Triferric Phosphate</i>
" " Sulphate of	<i>Ferric Sulphate</i>
Lead, Protoxide of	<i>Plumbic Oxide</i>
" Binoxide of	<i>Plumbic Peroxide</i>
" Acetate of	<i>Plumbic Acetate</i>
" Carbonate of	" <i>Carbonate</i>
" Chloride of	" <i>Chloride</i>
" Chromate of	" <i>Chromate</i>
" Nitrate of	" <i>Nitrate</i>
" Phosphate of (tribasic)	<i>Triplumbic Phosphate</i>
" Sulphate of	<i>Plumbic Sulphate</i>
" Tartrate of (neutral)	" <i>Tartrate</i>

COMMON NAME.	SYSTEMATIC NAME.
Lead, Sub Acetate of	<i>Diplumbic Acetate</i>
Lime, Carbonate of	<i>Calcic Carbonate</i>
“ Hydrate of	“ <i>Hydrate</i>
“ Sulphate of	“ <i>Sulphate</i>
“ Phosphate of (tribasic)	<i>Tricalcic Phosphate</i>
Lithium, Oxide of	<i>Lithic Oxide</i>
“ Carbonate of	“ <i>Carbonate</i>
“ Nitrate of	“ <i>Nitrate</i>
“ Sulphate of	“ <i>Sulphate</i>
Magnesium, Oxide of	<i>Magnesian Oxide</i>
“ Chloride of	“ <i>Chloride</i>
Magnesia, Carbonate of	“ <i>Carbonate</i>
“ Citrate of (neutral)	“ <i>Citrate</i>
“ Sulphate of	“ <i>Sulphate</i>
“ Phosphate of (tribasic)	<i>Trimagnesian Phosphate</i>
Manganese, Protoxide of	<i>Manganous Oxide</i>
“ Sesquioxide of	<i>Manganic Oxide</i>
“ Binoxide of	“ <i>Peroxide</i>
Manganic Acid	“ <i>Acid</i>
Per Manganic Acid	<i>Per Manganic Acid</i>
Manganese, Acetate of	<i>Manganous Acetate</i>
“ Chloride of	“ <i>Chloride</i>
“ Phosphate of (tribasic)	<i>Trimanganous Phosphate</i>
“ Sulphate of	<i>Manganous Sulphate</i>
Mercury, Suboxide of	<i>Mercurous Oxide</i>
“ Protoxide of	<i>Mercuric Oxide</i>
“ Subchloride of	<i>Mercurous Chloride</i>
“ Subiodide of	“ <i>Iodide</i>
“ Subnitrate of	“ <i>Nitrate</i>
“ Protochloride of	<i>Mercuric Chloride</i>
“ Protoiodide of	“ <i>Iodide</i>
“ Pronitrate of	“ <i>Nitrate</i>
“ Prosulphide of	“ <i>Sulphide</i>
Molybdenum, Protoxide of	<i>Molybdous Oxide</i>
“ Binoxide of	<i>Molybdic Oxide</i>
Molybdic Acid	“ <i>Acid</i>
Nickel, Protoxide of	<i>Nickeic Oxide</i>
“ Sesquioxide of	“ <i>Peroxide</i>
“ Acetate of	“ <i>Acetate</i>
“ Carbonate of	“ <i>Carbonate</i>
Nickel, Nitrate of	<i>Nickelic Nitrate</i>
“ Sulphate of	“ <i>Sulphate</i>
Osmous Acid	<i>Osmous Acid</i>
Osmic Acid	<i>Osmic Acid</i>
Palladium, Oxide of	<i>Palladic Oxide</i>
“ Chloride of	“ <i>Chloride</i>
“ Iodide of	“ <i>Iodide</i>

COMMON NAME.	SYSTEMATIC NAME.
Palladium Nitrate of	<i>Palladic Nitrate</i>
Platinum, Protoxide of	<i>Platinous Oxide</i>
"    Binoxide of	<i>Platinic Oxide</i>
"    Protochloride of	<i>Platinous Chloride</i>
"    Bichloride of	<i>Platinic Chloride</i>
"    Bisulphide of	" <i>Sulphide</i>
Potassium, Oxide of	<i>Potassic Oxide</i>
"    Bromide of	" <i>Bromide</i>
"    Chloride of	" <i>Chloride</i>
"    Cyanide of	" <i>Cyanide</i>
"    Ferrocyanide of	" <i>Ferro Cyanide</i>
"    Ferri cyanide of	" <i>Ferri Cyanide</i>
"    Iodide of	" <i>Iodide</i>
"    Sulphide of	" <i>Sulphide</i>
"    Sulphocyanide of	" <i>Sulpho Cyanide</i>
Potash, Acetate of	" <i>Acetate</i>
"    Bromate of	" <i>Bromate</i>
"    Carbonate of	" <i>Carbonate</i>
"    Bicarbonate of	<i>Hydropotassic Carbonate</i>
"    Chlorate of	<i>Potassic Chlorate</i>
"    Chromate of	" <i>Chromate</i>
"    Bichromate of	" <i>Di Chromate</i>
"    Cyanate of	" <i>Cyanate</i>
"    Nitrate of	" <i>Nitrate</i>
"    Nitrite of	" <i>Nitrite</i>
"    Manganate of	" <i>Manganate</i>
"    Permanganate of	" <i>Permanganate</i>
"    Oxalate of	" <i>Oxalate</i>
"    Binoxalate of	<i>Hydropotassic Oxalate</i>
"    Sulphite of	<i>Potassic Sulphite</i>
"    Sulphate of	" <i>Sulphate</i>
"    Bisulphate of	<i>Hydropotassic Sulphate</i>
"    Hyposulphate of	<i>Potassic Hyposulphate</i>
"    Hyposulphite of	" <i>Hyposulphite</i>
"    Silicate of	" <i>Silicate</i>
"    Tartrate of	" <i>Tartrate</i>
"    Bitartrate of	<i>Hydropotassic Tartrate</i>
Potassio Tartrate of Sodium	<i>Potassiosodic Tartrate</i>
"    Antimony	<i>Potassio Antimonic Tartrate</i>
Rhodium, Protoxide of	<i>Rhodous Oxide</i>
"    Sesquioxide of	<i>Rhodic Oxide</i>
Rubidium, Protoxide of	<i>Rubidic Oxide</i>
Ruthenium, Protoxide of	<i>Ruthenous Oxide</i>
"    Sesquioxide of	<i>Ruthenic Oxide</i>
Silver, Protoxide of	<i>Argentio Oxide</i>
"    Acetate of	" <i>Acetate</i>
"    Chloride of	" <i>Chloride</i>

COMMON NAME.	SYSTEMATIC NAME.
Silver, Chromate of	<i>Argentio Chromate</i>
“ Cyanide of	“ <i>Cyanide</i>
“ Nitrate of	“ <i>Nitrate</i>
“ Sulphate of	“ <i>Sulphate</i>
Sodium, Protoxide of	<i>Sodic Oxide</i>
“ Bromide of	“ <i>Bromide</i>
“ Chloride of	“ <i>Chloride</i>
“ Nitroprusside of	“ <i>Nitroprusside</i>
Soda, Ammonia-phosphate of	<i>Di-sodio-ammonic Phosphate</i>
“ Carbonate of	<i>Sodic Carbonate</i>
“ Bicarbonate of	<i>Hydrosodic Carbonate</i>
“ Formate of	<i>Sodic Formate</i>
“ Hydrate of	“ <i>Hydrate</i>
“ Iodate of	“ <i>Iodate</i>
“ Tribasic Phosphate of	
“ “ “ (neutral)	<i>Trisodic Phosphate</i>
“ “ “ (acid)	<i>Hydrodisodic Phosphate</i>
“ “ “	<i>Dihydrodisodic Phosphate</i>
“ Bibasic Phosphate of	
“ “ “ (neutral)	<i>Disodic Diphosphate</i>
“ “ “ (acid)	<i>Hydrosodic Diphosphate</i>
“ Monobasic Phosphate of	<i>Trisodic Triphosphate</i>
“ Silicate of	<i>Sodic Silicate</i>
“ Sulphate of	“ <i>Sulphate</i>
“ Hyposulphate of	“ <i>Hyposulphate</i>
“ Hyposulphite of	“ <i>Hyposulphite</i>
“ Sulphite of	“ <i>Sulphite</i>
“ Stannate of	“ <i>Stannate</i>
“ Tungstate of	“ <i>Tungstate</i>
“ Urate of	“ <i>Urate</i>
Strontium, Oxide of	<i>Strontic Oxide</i>
“ Acetate of	“ <i>Acetate</i>
“ Carbonate of	“ <i>Carbonate</i>
“ Chloride of	“ <i>Chloride</i>
“ Chlorate of	“ <i>Chlorate</i>
“ Oxalate of	“ <i>Oxalate</i>
“ Nitrate of	“ <i>Nitrate</i>
“ Phosphate of (tribasic)	<i>Trisrtronic Phosphate</i>
“ Sulphate of	<i>Strontic Sulphate</i>
“ Sulphide of	“ <i>Sulphide</i>
Thallium, Oxide of	<i>Thallic Oxide</i>
Tin, Protoxide of	<i>Stannous Oxide</i>
“ Bin oxide of	<i>Stannic Oxide</i>
“ Protochloride of	<i>Stannous Chloride</i>
“ Protosulphate of	“ <i>Sulphate</i>
“ Protosulphide of	“ <i>Sulphide</i>
“ Bichloride of	<i>Stannic Chloride</i>

COMMON NAME.	SYSTEMATIC NAME.
Titanium, Sesquioxide of	<i>Titanic Oxide</i>
Titanic Acid	<i>Titanic Acid</i>
Tungsten, Protoxide of	<i>Tungstic Oxide</i>
Tungstic Acid	<i>Tungstic Acid</i>
Uranium, Protoxide of	<i>Uranous Oxide</i>
“ Sesquioxide of	<i>Uranic Oxide</i>
“ Acetate of	“ <i>Acetate</i>
“ Chloride of	“ <i>Chloride</i>
“ Nitrate of	“ <i>Nitrate</i>
“ Sulphate of	“ <i>Sulphate</i>
Zinc, Protoxide of	<i>Zincic Oxide</i>
“ Acetate of	“ <i>Acetate</i>
“ Bromide of	“ <i>Bromide</i>
“ Carbonate of	“ <i>Carbonate</i>
“ Chloride of	“ <i>Chloride</i>
“ Cyanide of	“ <i>Cyanide</i>
“ Iodide of	“ <i>Iodide</i>
“ Nitrate of	“ <i>Nitrate</i>
“ Lactate of	“ <i>Lactate</i>
“ Sulphate of	“ <i>Sulphate</i>
<hr/>	
Hydrated Nitric Acid	<i>Hydric Nitrate</i>
“ Sulphuric Acid	“ <i>Sulphate</i>
“ Tribasic Phosphoric Acid	<i>Trihydric Phosphate</i>
“ Acetic Acid	<i>Hydric Acetate</i>
“ Carbonic Acid	“ <i>Carbonate</i>
“ Chromic Acid	“ <i>Chromate</i>
Boracic Acid	<i>Boraic Anhydride</i>
Hydrochloric Acid	<i>Hydric Chloride</i>
Chromic Acid	<i>Chromic Anhydride</i>
Hydrobromic Acid	<i>Hydric Bromide</i>
Sulphuric Acid (anhydrous)	<i>Sulphuric Anhydride</i>
Hydrated Chloric Acid	<i>Hydric Chlorate</i>
Blue Stone	<i>Cupric Sulphate</i>
Blue Vitriol	“ “
White “	<i>Zincic Sulphate</i>
Green “	<i>Ferrous Sulphate</i>
Copperas	“ “
Spirits of Salts	<i>Hydric Chloride</i>
Vitriol	“ <i>Sulphate</i>
Aqua Fortis	“ <i>Nitrate</i>
Lunar Caustic	<i>Argentive Nitrate</i>
Sugar of Lead	<i>Plumbic Acetate</i>
Salts of Saturn	“ “

TRADE NAME.	SYSTEMATIC NAME.
Salts of Sorrel	<i>Hydro Potassic Oxalate</i>
" Lemon	" "
Cream of Tartar	" <i>Tartrate</i>
Tartar Emetic	<i>Potassio Antimonic Tartrate</i>
Pearlash	<i>Potassic Carbonate</i>
Milk of Sulphur	<i>Sulphur (precipitated)</i>
Flowers of Sulphur	" ( <i>sublimed</i> )
Saltpetre	<i>Potassic Nitrate</i>
White Lead	<i>Plumbic Carbonate</i>
Black "	<i>Carbon</i>
Arsenic	<i>Arsenious Acid</i>
Vermillion	<i>Mercuric Per Sulphide</i>
Verdigris	<i>Cupric Acetate</i>
Butter of Antimony	<i>Antimonic Chloride</i>
Sal Ammoniac	<i>Ammonic Chloride</i>
Plaster of Paris	<i>Calcic Sulphate</i>
Borax	<i>Sodic Di Borate</i>
Liver of Sulphur	<i>Potassic Sulphide</i>
Soda	<i>Sodic Carbonate</i>
Glauber's Salts	" <i>Sulphate</i>
Epsom "	<i>Magnesian Sulphate</i>
Calomel	<i>Mercurous Chloride</i>
Corrosive Sublimate	<i>Mercuric Chloride</i>



**THE METALLOIDS:**

**OR**

**NON-METALLIC ELEMENTS.**



## The METALLOIDS, or NON-METALLIC ELEMENTS.

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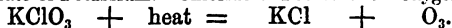
### CHAPTER I.

#### OXYGEN.

Smybol, O ; Equivalent, 16 ; volume, 1.

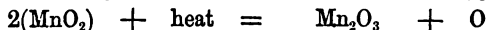
1. PREPARATION :—METHOD No. I.—To obtain this element, heat in a retort some chloriate of potassium, *potassic chlorate*. It is advisable to add a little binoxide of manganese, *manganic peroxide*, as the gas is then given off at a much lower temperature than when the chlorate is heated alone. The heat decomposes the salt, one equivalent of chloride of potassium, *potassic chloride*, being left in the retort along with the unaltered manganese, and three equivalents of oxygen are evolved, thus :—

Chlorate of Potassium. Chloride of Potassium. Oxygen.



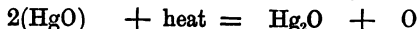
METHOD II.—A more economical process of preparing oxygen is to heat red hot two equivalents of binoxide of manganese, when one equivalent of oxygen is given off and sesquioxide of manganese, *manganic oxide*, remains in the retort, thus :—

Bin oxide of manganese. Sesquioxide of manganese. Oxygen.



METHOD III.—By heating two equivalents of red oxide of mercury, *mercuric oxide*, when suboxide of mercury, *mercurous oxide* is left in the retort, one equivalent of oxygen being set free, thus :—

Red oxide of mercury. Suboxide of mercury. Oxygen.



METHOD IV.—A saturated solution of bleaching powder is introduced into a retort, and a few drops of nitrate of cobalt

added ; upon applying heat, oxygen gas is evolved. The oxide of cobalt formed acts by catalysis upon the hypochlorite of calcium, changing it to chloride of calcium and oxygen.

PROPERTIES : No colour, taste, or smell. It is a little heavier than common air, 100 cubic inches weighing 94.29 grains. It is the main supporter of life and combustion, and unites with the elementary bodies, forming an important class of compounds called oxides.

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### OZONE.

2. When electric sparks are passed through dry oxygen or atmospheric air, a peculiar odour is produced. The same odour may be imparted to moist oxygen by allowing phosphorus to remain in contact with it for some time. Ozone may be immediately detected, if a piece of paper prepared with a mixture of starch paste and iodide of potassium, *potassic iodide*, be held in the ozonised air, or oxygen, the paper becoming blue by the action of the liberated iodine of the iodide of potassium upon the starch forming iodide of starch.

There is great difficulty in deciding whether ozone is to be regarded as oxygen in an allotropic state, or a compound of oxygen and hydrogen ; the author is of the former opinion.

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### HYDROGEN.

Symbol, H ; Equivalent, 1 ; Volume 1.

3. PREPARATION :—METHOD I.—Hydrogen gas may best be obtained by the action of zinc or iron and sulphuric acid, *hydric sulphate*, on water. For this purpose iron filings or granulated zinc are placed in a gas bottle along with sulphuric acid diluted with about six times its bulk of water. Two equivalents of the gas are given off with brisk effervescence from the surface of the metal, which rapidly dissolves, forming one equivalent of a sulphate of zinc or iron, *zincic or ferrous sulphate*, thus—

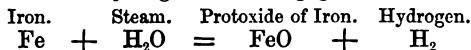
Zinc. Sulphuric Acid. Water. Sulphate of Zinc and Water. Hydrogen  

$$\text{Zn} + \text{H}_2\text{SO}_4 + \text{H}_2\text{O} = \text{ZnSO}_4, \text{H}_2\text{O} + \text{H}_2$$

Or Iron. Sulphuric Acid. Water. Sulphate of Iron and Water. Hydrogen.  

$$\text{Fe} + \text{H}_2\text{SO}_4 + \text{H}_2\text{O} = \text{FeSO}_4, \text{H}_2\text{O} + \text{H}_2.$$

METHOD II.—When an equivalent of steam is passed through a red hot gun barrel containing iron turnings, one equivalent of protoxide of iron, *ferrous oxide*, is formed, and two equivalents of hydrogen are disengaged, thus :—



PROPERTIES : No colour, taste, or smell. It is the lightest body known, 100 cubic inches only weighing 2·14 grains. It is a non-supporter of life and combustion, is highly combustible, burning with a pale flame, generating at the same time great heat, with the formation of water.

### WATER.

Symbol,  $\text{H}_2\text{O}$  ; Equivalent, 18.

4. When two volumes of hydrogen and one volume of oxygen are exploded by means of the electric spark, they unite and condense to two volumes of water vapour.

PROPERTIES : Pure water is colourless, tasteless, and inodorous. In nature it is seldom found pure, being generally contaminated with substances dissolved from the earth or the atmosphere. It freezes at 32 degrees Fahr., and boils at 212 degrees Fahr. Water combines with many substances to form a class of compounds called hydrates. Example : Lime, *calcic-oxide*, combines with water in the process of slacking, and the dry powder which is formed is called hydrate of calcium. Often the affinity between the water and the substance is so great that heat is incapable of decomposing the compound. Examples : Hydrate of potassium and sodium, *potassic and sodic hydrate*.

5. Anhydrous compounds do not contain water.

6. Water unites with many salts during crystallization. Crystallized sulphate of copper, *cupric sulphate*, contains four equivalents of water of crystallization and one of constitution. It is of a blue colour. When carefully dried it gives off the water of crystallization which it contains and becomes white.

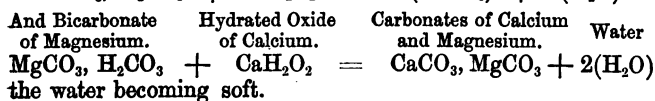
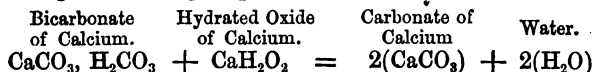
Water of constitution is distinguished from water of crystallization by not being expelled at a temperature of about 212 degrees Fahr.

7. Efflorescent compounds are those which lose water when exposed to the air. Example: Crystals of carbonate of sodium, *sodic carbonate*.

8. Deliquescent compounds are those which absorb water from the atmosphere, becoming moist after a time. Example: Chloride of calcium, *calcic chloride*.

#### HARDNESS OF WATER.

9. The hardness of water is generally due to the presence of bicarbonates and sulphates of calcium and magnesium in solution. Permanent hardness is caused by the sulphate of calcium and magnesium; temporary hardness by carbonic acid and the bicarbonates of calcium and magnesium, for on the addition of one equivalent of hydrated oxide of calcium to each equivalent of bicarbonate, the whole of the calcium and magnesium are precipitated as carbonates, thus:—



The comparative hardness of water can be determined by means of a standard alcoholic solution of soap, called Clarke's Soap Test. A portion of the water, the hardness of which we wish to find, is measured into a stoppered bottle (which it should not more than half fill), and the soap test added from an alkalimeter, a few drops at a time, the bottle being well agitated after each addition. This process is continued until a permanent lather is produced lasting about five minutes.

The sample of water which requires the smallest number of measures of soap test is the softest, and the sample which takes the greatest number of measures is necessarily the hardest.

#### BINOXIDE OF HYDROGEN.

Symbol,  $\text{H}_2\text{O}_2$ ; Equivalent, 34.

10. PREPARATION: Formed by dissolving the binoxide of barium, *baric binoxide*, in dilute hydrochloric acid, *hydric-*

*chloride*, kept cool by ice, and then precipitating the barium as sulphate, by means of sulphuric acid, *hydric sulphate*. Binoxide of barium is prepared by exposing oxide of barium at a red heat to the action of a stream of oxygen gas.

**PROPERTIES:** A colourless, inodorous liquid, possessing remarkable bleaching properties. It is decomposed by a slight heat, and when heated to about 212 degrees Fahr., it explodes with violence.

### ATMOSPHERIC AIR.

11. Air consists of a mechanical mixture of nitrogen and oxygen gases, with a small proportion of carbonic acid gas, and water vapour. The per centage by weight is about—

Nitrogen .....	77
Oxygen .....	23
	<hr/>
	100

By volume—

Nitrogen .....	79
Oxygen .....	21
	<hr/>
	100

The mean of a number of analyses of air (collected in the country, some distance from town, and at different seasons of the year) gave the author the following numbers :—

Oxygen..... 20·94 per cent., by volume.  
And Carbonic Acid ... 0·04 “ “

In towns a larger proportion of carbonic acid is found to exist in the atmosphere.

The specific gravity of common air is considered as 1·000, it being taken as a standard, to which all other gases and vapours are referred.

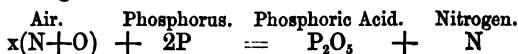
100 cubic inches of air weigh 31·01 grains at 60 degrees Fahrenheit, and 80 inches barometric pressure.

### NITROGEN.

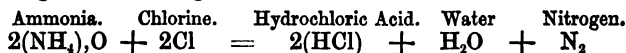
Symbol, N; Equivalent, 14; Volume, 1;

12. **PREPARATION:—METHOD I.**—This gas may be prepared by burning phosphorus in a confined portion of air under a

bell jar standing over water. The phosphorus unites with the oxygen of the air, forming phosphoric acid, *phosphoric anhydride*, which, being soluble in water, is gradually absorbed, forming hydrated phosphoric acid, *hydric phosphate*, and leaving nitrogen, thus :—



METHOD II.—By passing chlorine gas through a solution of ammonia, *ammonic hydrate*, which is a compound of nitrogen, hydrogen, and oxygen, the chlorine unites with the hydrogen, setting free the nitrogen, thus :—



Note. Care must be taken not to carry the process too far, otherwise an explosive compound, chloride of nitrogen, may be formed.

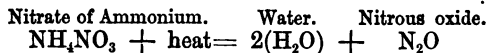
PROPERTIES.—Without colour, taste, or smell, non-supporter of life and combustion ; it is rather lighter than the air, 100 cubic inches weighing 80·14 grains. Nitrogen combines with oxygen, forming an important class of compounds.

This gas is often called *azote*.

## NITROUS OXIDE.

Symbol,  $\text{N}_2\text{O}$  ; Equivalent, 44.

13. PREPARATION.—This gas is best prepared by heating nitrate of ammonium, *ammonic nitrate*, in a retort. The salt is decomposed by the action of the heat, being resolved into one equivalent of nitrous oxide and two equivalents of water, thus :—

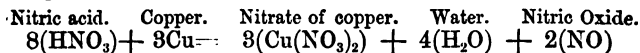


PROPERTIES: A colourless gas, having a sweet taste ; powerful supporter of combustion, 100 cubic inches weigh 47·29 grains. From the curious physiological properties of this intoxicating gas, it has been named laughing gas. It is also called protoxide of nitrogen.

## NITRIC OXIDE.

Symbol, NO ; Equivalent, 30.

14. PREPARATION.—When eight equivalents of nitric acid, *hydric nitrate*, act upon three equivalents of copper filings in a retort, with the aid of a gentle heat, a colourless gas is given off, and three equivalents of nitrate of copper, *cupric nitrate*, along with four equivalents of water are formed, thus:—



Nitric oxide or binoxide of nitrogen consists of equal volumes of nitrogen and oxygen gases, united without condensation.

PROPERTIES.—A colourless gas, 100 cubic inches weigh 82.22 grains. It extinguishes the flame of most burning bodies ; phosphorus, however, burns with a bright light when ignited and plunged into a jar of the gas. The most characteristic property of nitric oxide is the formation of orange red fumes of nitrous and hyponitric acids, *nitrous and hyponitric anhydrides*, when mixed with oxygen gas or air.

## NITROUS ACID.

*Nitrous Anhydride.*Symbol, N<sub>2</sub>O<sub>3</sub> ; Equivalent, 76.

15. PREPARATION :—METHOD I. When four volumes of nitric oxide are mixed with one volume of oxygen, and the gases exposed to a low temperature, a green liquid, nitrous acid, is produced.

METHOD II.—By the action of strong nitric acid, *hydric nitrate*, on arsenious acid, *arsenious anhydride*, assisting the action by the application of a very gentle heat, orange red gas, which is impure nitrous acid, is evolved.

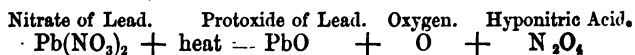
PROPERTIES.—An orange red gas at ordinary temperatures. It is decomposed by water being changed into nitric acid and nitric oxide gas.

## HYPONITRIC ACID.

*Hyponitric Anhydride.*Symbol, N<sub>2</sub>O<sub>4</sub> ; Equivalent, 92.

16. PREPARATION : This compound is formed when nitric oxide is mixed with an excess of oxygen or air. It is usually

prepared from nitrate of lead, *plumbic nitrate*, by the application of heat; protoxide of lead, *plumbic oxide*, remains in the retort, and oxygen and hyponitric acid gases being given off. The receiver must be placed in a freezing mixture, to assist the condensation of the acid.



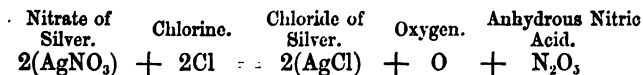
**PROPERTIES:** It is decomposed by water, being changed into nitric acid and nitric oxide gas. At a low temperature it is a colourless liquid, but at ordinary temperatures has a red colour, and evolves red fumes.

### NITRIC ACID (Anhydrous).

*Nitric Anhydride.*

Symbol,  $\text{N}_2\text{O}_5$ ; Equivalent, 108.

17. **PREPARATION:** When nitrate of silver, *argentic nitrate*, is acted upon by chlorine gas, chloride of silver, *argentic chloride*, is formed, whilst oxygen and anhydrous nitric acid are liberated, thus:—



**PROPERTIES:** Colourless crystallizable substance, dissolves in water with evolution of heat, forming hydrated nitric acid, *hydric nitrate*.

### NITRIC ACID. (Hydrated.)

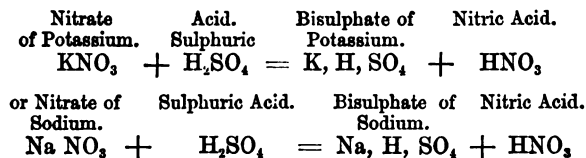
*Hydric Nitrate.*

Symbol,  $\text{HNO}_3$ ; Equivalent, 63.

18. **PREPARATION:** This important acid is obtained by heating a mixture of nitrate of potassium, *potassic nitrate*, or nitrate of sodium, *sodic nitrate*, with sulphuric acid, *hydric sulphate*. A liquid distils over, which, when pure, is quite colourless, but is usually of a yellow colour, due to the



presence of nitrous and hyponitric acids. The following equations explain the action which takes place in the retort :



The salt which remains in the retort when nitric acid is prepared from nitrate of potassium is bisulphate of potassium. If prepared from nitrate of sodium, bisulphate of sodium is formed.

**PROPERTIES.**—A strong acid liquid, fuming when exposed to the air, stains the skin yellow. It is used extensively in the arts and manufactures as a solvent for the metals, which it dissolves with the evolution of reddish yellow fumes. It has no action upon gold or platinum. A mixture of nitric and hydrochloric acids, is called *Aqua Regia*, it dissolves gold and platinum readily, forming chlorides.

Tests for nitric acid, free or in combination :—

- 1.—Warm the solution with a few drops of sulphuric acid and sulphate of indigo, the blue colour of which will be destroyed in a few minutes if nitric acid be present.
- 2.—Place a crystal of protosulphate of iron, *ferrous sulphate*, in the solution, and then add a few drops of sulphuric acid ; the crystal will become of a dark brown colour if left undisturbed for a short time. The protosulphate of iron reduces the nitric acid to the condition of bi-oxide of nitrogen, which imparts the dark colour to the iron solution.
- 3.—Add a few copper filings and a small quantity of sulphuric acid, apply a gentle heat, when reddish fumes will be evolved.

## AMMONIA. (Gas).

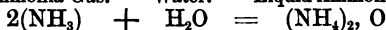
Symbol,  $\text{NH}_3$ ; Equivalent, 17.

## LIQUID AMMONIA OR OXIDE OF AMMONIUM.

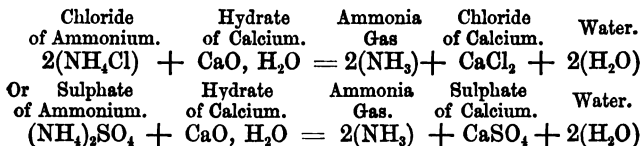
Symbol,  $(\text{NH}_4)_2\text{O}$ ; Equivalent, 52.

19.—PREPARATION.—For commercial purposes this gas is obtained from the gas or ammonia water, which is one of the products of coal gas manufacture, and consists principally of carbonate and sulphide of ammonium with water. When heated with hydrate of calcium, *calcic hydrate*, ammonia gas passes over and may be condensed in water which has a great affinity for it, being capable of dissolving upwards of six hundred times its volume of ammonia gas, liquid ammonia or oxide of ammonium, *ammonic oxide*, being formed, thus :—

Ammonia Gas.      Water.      Liquid Ammonia.



In the laboratory ammonia gas is prepared from chloride or sulphate of ammonium, *ammonic chloride or sulphate*, by the action of hydrate of calcium, with the aid of a gentle heat. Chloride or sulphate of calcium, *calcic chloride or sulphate*, remains in the retort, ammonia gas being liberated thus :—



PROPERTIES.—The gas is colourless having a very strong characteristic odour, it has an alkaline reaction, turning red litmus paper blue, and yellow turmeric paper reddish brown. One hundred cubic inches weigh 18.26 grains.

The properties of liquid ammonia are almost identical with those of the gas. It is a valuable alkaline re-agent, and is extensively used in the arts and manufactures. The strength of a solution of ammonia may be determined by means of a standard test acid, which process is described under alkalimetry, § 107.

When common liquid ammonia enters into combination with acids, &c., it forms crystallizable ammonium salts; the

base is considered to be ammonium,  $\text{NH}_4$ , and the salts are therefore written, thus :—

Sulphate of Ammonium	.....	$(\text{NH}_4)_2 \text{SO}_4$
Carbonate	“	..... $(\text{NH}_4)_2 \text{CO}_3$
Nitrate	“	..... $\text{NH}_4 \text{NO}_3$
Chloride	“	..... $\text{NH}_4 \text{Cl}$
Acetate	“	..... $\text{NH}_4 \text{C}_2 \text{H}_3 \text{O}_2$

The preparation and properties of the salts of ammonium are described under the subject of ammonium, Chapter II.

## CARBON.

Symbol, C ; Equivalent, 12.

20. This element exists in three distinct modifications or conditions. First, in a crystallized state, as the diamond ; second, as graphite or black lead (plumbago) ; third, as lamp black.

Lamp black and charcoal are the best examples that can be given of carbon in the common uncrystallizable condition.

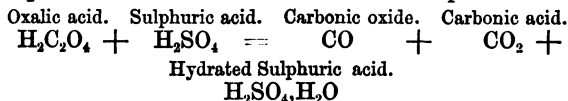
Carbon is remarkable for its insolubility in acids, alkalis, &c. When a small portion is burnt in a large gas jar of oxygen, carbonic acid gas is formed ; when, however, the carbon is in excess of the oxygen an imperfect combustion takes place and a portion of carbonic oxide is invariably formed.

## CARBONIC OXIDE.

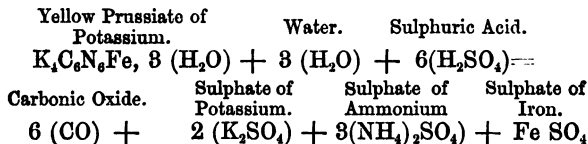
Symbol, CO ; Equivalent, 28.

21. PREPARATION :—METHOD I.—By the action of sulphuric acid, *hydric sulphate*, assisted by heat, on oxalic acid, carbonic oxide and carbonic acid gases are evolved. The mixed gases are passed through a solution of caustic potash before collecting in gas jars at the pneumatic trough. The caustic potash

having a great affinity for the carbonic acid absorbs it, but allows the carbonic oxide gas to pass through unchanged. The following equation will explain the decomposition which takes place when oxalic acid is heated with sulphuric acid :—



METHOD II.—When one equivalent of yellow prussiate of potassium, *potassic ferrocyanide*, is heated with six or eight equivalents of sulphuric acid, *hydric sulphate*, and three equivalents of water, pure carbonic oxide gas is given off, and sulphates of potassium, ammonium, and iron remain in the retort, thus :—

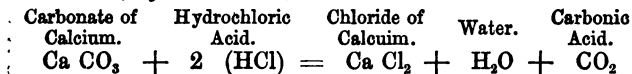


PROPERTIES.—A combustible gas burning with a blue flame, and becoming converted into carbonic acid gas. It is colourless, almost inodorous, but a poisonous gas; 100 cubic inches weigh 80.22 grains.

### CARBONIC ACID.

Symbol,  $\text{CO}_2$ ; Equivalent, 44.

22.—PREPARATION.—This gas is formed when carbon is burnt in oxygen or air. It is easily prepared from chalk, carbonate of calcium, *calcic carbonate*, by the action of hydrochloric acid, *hydric chloride*, thus :—



PROPERTIES.—A colourless gas, having a slight acid taste, cannot be respired for more than a few seconds, in consequence of it producing asphyxia. It is a heavy gas, 100 cubic inches weighing 47.28 grains, extinguishes flame, turns lime water milky with the formation of carbonate of calcium. It is given

off from the lungs during respiration, also during fermentation and germination. After damp or choke damp of our coal mines contains a large proportion of carbonic acid gas, to which it owes its deadly effects. Under a great pressure and at a low temperature, carbonic acid gas liquifies.

Carbonic acid unites with the bases forming a series of important compounds called carbonates.

### LIGHT CARBIDE OF HYDROGEN.

Symbol,  $\text{CH}_4$ ; Equivalent, 16.

23. This gas is also called marsh gas.

PREPARATION.—When a mixture of acetate of sodium, *sodic acetate*, hydrate of potassium, *potassic hydrate*, and quick lime, *calcic oxide*, are strongly heated, the gas is disengaged, whilst carbonates of calcium, potassium, and sodium, along with hydrate of potassium and calcium, remain in the retort.

PROPERTIES.—Colourless, almost inodorous gas, inflammable, burning with a pale yellow flame, forming carbonic acid and water; non-supporter of life and combustion; 100 cubic inches only weigh 17.4 grains. A mixture of light carbide of hydrogen and chlorine gas do not enter into chemical combination when kept in the dark.

### HEAVY CARBIDE OF HYDROGEN.

Symbol,  $\text{C}_2\text{H}_2$ ; Equivalent, 28.

24. This gas is also called olefiant gas.

PREPARATION.—When alcohol, mixed with six or seven times its weight of sulphuric acid, *hydric sulphate*, is heated in a gas flask, impure heavy carbide of hydrogen is evolved. If the gas is passed through two wash bottles, one containing caustic potash, and the other containing sulphuric acid, most of the impurities will be removed, the caustic potash absorbing the carbonic and sulphurous acids, and the sulphuric acid the ether vapour, &c.

PROPERTIES.—A colourless gas, having a faint odour of garlic, inflammable, burning with a brilliant white light; a non-supporter of life and combustion; 100 cubic inches weigh 80.57 grains. When a mixture of heavy carbide of hydrogen

and chlorine gas are exposed to the action of light, they unite in equal volumes, forming Dutch liquid,  $C_2H_4Cl_2$ ; they also combine gradually in the dark.

### SULPHUR.

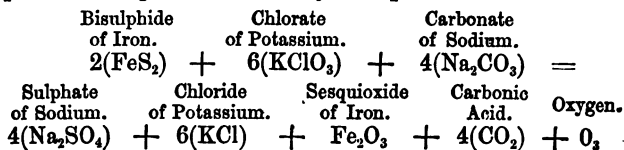
Symbol, S; Equivalent, 32; Volume, 1.

25. This element exists abundantly in Sicily, in the native state, also in this country in combination with iron, copper, zinc, lead, calcium, barium, &c., as sulphide and sulphate.

PROPERTIES.—Pale yellow brittle substance, melts when strongly heated, and distils or sublimes into the receiver. It burns with a blue flame, producing a suffocating odour, which is due to the formation of sulphurous acid gas. By the action of different degrees of heat, many remarkable changes and modifications of condition of sulphur are produced. Common sulphur is soluble in bisulphide of carbon; one of its modifications, however, which is of a reddish colour, is perfectly insoluble in this fluid. Sulphur unites with oxygen to form a series of important acid compounds. It enters into combination with hydrogen to form sulphide of hydrogen.

#### QUANTITATIVE ESTIMATION OF THE PER-CENTAGE OF SULPHUR IN MINERALS.

26. Twenty grains of the finely powdered mineral, for example, iron pyrites,  $FeS_2$ , are intimately incorporated with about 200 grains of a mixture of equal parts of chlorate of potassium and carbonate of sodium, and then gradually introduced into a red hot porcelain crucible. The whole is strongly heated for some minutes, when sulphate of sodium, chloride of potassium, and oxide of iron are formed, and remain in the crucible with the excess of carbonate of sodium, &c., whilst carbonic acid and oxygen gases are evolved. The reaction of the chlorate of potassium and carbonate of sodium upon the bisulphide of iron may be expressed thus:—



The mass, upon cooling, is treated with water, acidulated with nitric acid, and then filtered. To the clear solution chloride of barium, *baric chloride*, is added in excess to precipitate the sulphuric acid in combination with barium as sulphate. The precipitate is collected on a filter, well washed with water, dried, burned, and lastly weighed. Every 238·18 grains of sulphate of barium, *baric sulphate*, represent 32 grains of sulphur.

EXAMPLE :—Supposing that the precipitate obtained by treating 20 grains of the mineral by the process described above weighed 62·75 grains, then the following statement will give the amount of sulphur contained in that quantity :—

$$\text{As } 238\cdot18 : 62\cdot75 : : 32 : x = 8\cdot61$$

$$\begin{array}{r} 12550 \\ 18825 \\ \hline 2008\cdot00 \\ 186544 \\ \hline 142560 \\ 139908 \\ \hline 26520 \\ 23318 \\ \hline 3202 \end{array}$$

The quotient (8·61) is the determined quantity of sulphur yielded from 20 grains of the mineral, and therefore requires multiplying by five to give the per-centage.

$8\cdot61 \times 5 = 43\cdot05 =$  the per-centage of sulphur contained in the mineral.

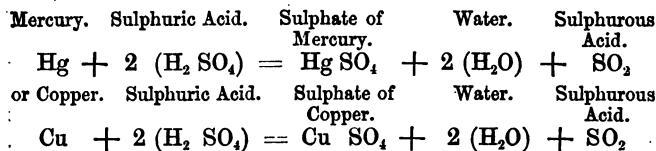
### SULPHUROUS ACID (GAS).

*Sulphurous Anhydride.*

Symbol,  $\text{SO}_2$ ; Equivalent 64.

27. PREPARATION.—This gas is formed when sulphur is burned in oxygen or air. It is generally prepared from two

equivalents of sulphuric acid, *hydric sulphate*, by the action of one equivalent of mercury or copper (filings), assisted by heat, thus :—



It can also be readily prepared by heating a mixture of sulphuric acid and sulphur.

**PROPERTIES.**—A colourless gas, with a suffocating odour ; non-supporter of life and combustion ; a heavy gas, 100 cubic inches weighing 68·70 grains. It is capable of being condensed to the condition of a colourless liquid when submitted to pressure at a low temperature. It is soluble in water, forming a strongly acid liquid ; possesses considerable bleaching properties, being used in the arts and manufactures for bleaching straw, woollen materials, &c. It unites with the bases forming a class of compounds called sulphites.

### SULPHURIC ACID (Anhydrous).

*Sulphuric Anhydride.*

Symbol,  $\text{SO}_3$  ; Equivalent, 80.

**28. PREPARATION.**—If fuming Nordhausen sulphuric acid be carefully distilled, a white crystalline body is formed in the receiver, which is anhydrous sulphuric acid.

**PROPERTIES.**—When thrown in water, it hisses like a red hot iron, combining with the water, for which it has a great affinity, forming hydrated sulphuric acid, *hydric sulphate*. If the crystals are left exposed to the air, they soon absorb moisture and become converted into liquid acid.

### SULPHURIC ACID. (Hydrated).

*Hydric Sulphate.*

Symbol,  $\text{H}_2\text{SO}_4$  ; Equivalent, 98.

**29.**—It is commercially known by the name of oil of vitriol.

#### MANUFACTURE OF SULPHURIC ACID.

This acid is prepared commercially in immense quantities from sulphur or sulphur pyrites, which is burnt in kilns with





Sulphuric acid having a great affinity for water, it extracts it from organic substances, setting carbon free with the production of a black colour.—Ex. When sulphuric acid is poured upon sugar, cotton, linen, wood, paper, &c., a black colour is developed after a time.

### NORDHAUSEN SULPHURIC ACID.

Symbol,  $\text{H}_2\text{SO}_4, \text{SO}_3$ .

30. This acid is prepared by distilling partially dried proto-sulphate of iron, *ferrous sulphate*, in fire clay retorts, at a red heat. The salt suffers decomposition, oxides of iron being left in the retort, and fuming Nordhausen sulphuric acid distils into the receiver.

### ACIDIMETRY.

31. Acidimetry is the process of determining the amount of acid contained in a weighed quantity of an acid, by means of a standard solution of test alkali.

The test alkali is added from an alkalimeter to the diluted acid until it is neutralized. This point is ascertained by the reaction of the solution upon tincture of litmus and litmus paper in the manner described under the subject of alkalimetry. (See par. 107.)

### PREPARATION OF THE TEST ALKALI.

Dissolve 530 grains of pure anhydrous carbonate of sodium, *sodic carbonate*, in 1,000 alkalimeter measures of water. Every 100 measures of this standard solution will require the following amounts of the respective acids to effect its perfect neutralization.

100 measures of test alkali are equivalent to sulphuric acid .....				(anhydrous)	40 grains
"	"	"	nitric acid	"	54 "
"	"	"	hydrochloric acid	"	36.5 "
"	"	"	acetic acid	"	51 "
"	"	"	oxalic acid	(crystals)	63 "
"	"	"	tartaric acid	"	75 "
"	"	"	citric acid	"	70 "

When testing a sample of acid, weigh 100 grains, dilute with about two ounces of water, colour the liquid red with tincture of litmus; then add the test alkali carefully until the solution ceases to have any effect upon blue or red litmus paper, the operation is then finished. Now read off the scale of the alkalimeter the number of measures which have been employed, and state by simple proportion as 100 measures of the test alkali is to the equivalent of the acid, whose per centage is to be determined, so is the number of measures used, to the per centage of acid contained in the sample.

EXAMPLE.—100 grains of a sample of acetic acid took 71 measures of test alkali for its neutralization. Upon referring to the above table for the strength of the test alkali, we find 100 measures are equivalent to 51 grains of anhydrous acetic acid; then

$$\text{As } 100 : 51 :: 71 : x = 36.21$$

71

51

357

$$100 \mid 36.21$$

36.21

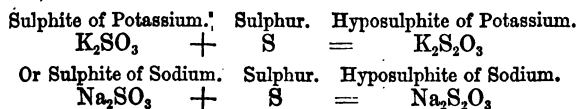
36.21 = the per-centage of anhydrous acetic acid contained in the sample.

### HYPOSULPHUROUS ACID. (Anhydrous.)

*Hyposulphurous Anhydride.*

Symbol,  $\text{S}_2\text{O}_2$ ; Equivalent, 96.

32. This acid has not been isolated—it is only known in combination with bases. When sulphites of potassium or sodium, *potassic or sodic sulphites*, are dissolved in water and sulphur added, and the liquor digested at a gentle heat, a portion of the sulphur is dissolved entering into combination with the sulphite forming hyposulphite of potassium or sodium, thus:—



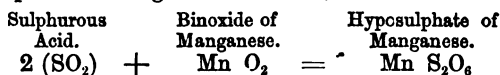
Hyposulphites are decomposed by acids, sulphurous acid gas being evolved and sulphur precipitated. The sodium salt (hyposulphite of sodium) is extensively used in photography for fixing or dissolving certain silver compounds.

### HYPOSULPHURIC ACID. (Anhydrous).

*Hyposulphuric Anhydride.*

Symbol,  $S_2O_5$ .

33.—This acid is prepared by passing a stream of sulphurous acid gas through a mixture of binoxide of manganese, *manganic peroxide*, and water, the whole being kept well agitated. Hyposulphate of manganese is formed, thus :—



If the hyposulphate of manganese, *manganous hyposulphate*, be decomposed by hydrate of barium, and lastly the barium salt be decomposed by dilute sulphuric acid, sulphate of barium is precipitated, and hyposulphuric acid  $H_2S_2O_5$ , *hydric hyposulphate*, remains in solution.

When hyposulphates are strongly heated, they suffer decomposition, separating into sulphurous and sulphuric acids.

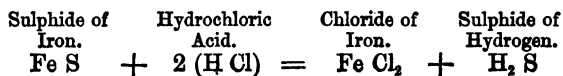
34.—The trithionic  $S_3O_6$ , tetrathionic  $S_4O_6$ , and pentathionic acids  $S_5O_6$ , of this series have no commercial value.

### SULPHIDE OF HYDROGEN. (Hydrosulphuric Acid.)

*Hydric Sulphide.*

Symbol,  $H_2S$ ; Equivalent, 34.

35.—PREPARATION.—This gas is generated in abundance, when hydrochloric acid, *hydric chloride*, is added to sulphide of iron, *ferrous sulphide*; chloride of iron, *ferrous chloride*, is formed, and sulphide of hydrogen being evolved, thus :—



**PROPERTIES.**—A colourless gas, having a very offensive odour resembling rotten eggs ; non-supporter of combustion, poisonous, inflammable, burning with a pale flame.

It is a powerful reducing agent, readily changing acid solutions of ferric salts, &c., to the condition of ferrous salts, &c.

The property that this gas possesses of precipitating as sulphides most of the metals from their solutions has been applied to many useful purposes in the laboratory ; one of the most important being the classification of the metals into groups with the aid of hydrosulphate of ammonium, *ammonic sulphide*, and alkaline carbonates.

The following are some of the reactions which sulphide of hydrogen produces, with solutions of the metals :—

Bismuth in acid solutions, a black precipitate.

Lead “ “ “ “

Copper “ “ “ “

Silver “ “ “ “

Gold “ “ “ “

Platinum “ “ “ “

Cadmium “ “ yellow “

Arsenic “ “ “ “

Antimony “ “ an orange red “

Zinc “ “ no precipitate

Zinc in neutral “ a white precipitate

Cobalt “ “ black “

Nickel “ “ “ “

## SELENIUM.

Symbol, Se ; Equivalent, 79 ; Volume, 1.

36. This element resembles sulphur in most of its chemical relations. It is a reddish brown, solid body, insoluble in water, slightly soluble in bisulphide of carbon. There are three oxides, two of which, selenous acid  $\text{SeO}_2$ , and selenic acid  $\text{SeO}_3$  are analogous to sulphurous and sulphuric acids. It also unites with hydrogen to form selenide of hydrogen  $\text{H}_2\text{Se}$ , which gas departs itself with solutions of metallic salts similar to that of sulphide of hydrogen.

## PHOSPHORUS.

Symbol, P; Equivalent, 81; Volume,  $\frac{1}{2}$ .

37. PREPARATION.—This element is prepared from burnt bones, which consist principally of phosphate of calcium, *ter-calcic phosphate*. Powdered bones are treated with dilute sulphuric acid, *hydric sulphate*; sulphate of calcium, *calcic sulphate*, is precipitated at the bottom of the vat, and impure phosphoric acid remains in solution. The solution is then drawn off, mixed with powdered charcoal, evaporated to dryness, and distilled in a stone ware or iron retort. The volatile products are passed through a condenser containing cold water; impure phosphorus settles to the bottom of the water, whilst carbonic oxide and carbonic acid gases escape into the air.

PROPERTIES.—Common phosphorus resembles white wax in appearance. It is poisonous, insoluble in water, soluble in bisulphide of carbon; it is highly inflammable, burning with a bright white light, producing white fumes of anhydrous phosphoric acid, *phosphoric anhydride*. When a piece of phosphorus is exposed to the air, white fumes of anhydrous phosphorous acid, *phosphorous anhydride*, are produced.

Red or amorphous phosphorus is obtained when common phosphorus is heated with exclusion from air for some days at a temperature of from 460 to 480 degrees Fahrenheit. It is of a reddish brown colour, insoluble in bisulphide of carbon, and does not fume when exposed to the air. It is reconverted into common phosphorus by distillation.

Both kinds of phosphorus are extensively used in the manufacture of lucifer matches. Phosphorus combines with oxygen to form several acid compounds, and with hydrogen to form phosphides of hydrogen.

---

HYPO-PHOSPHOROUS ACID (Hy drated).*Hydric Hypo-phosphite.*

Symbol, HPO; Equivalent, 48.

38.—This acid is not known in the anhydrous state.

PREPARATION.—The acid is formed when phosphorus is boiled with a solution of hydrate of barium, *baric hydrate*. Phosphide of hydrogen gas is evolved and phosphate and hypo-

phosphite of barium being formed. The insoluble phosphate of barium  $\text{Ba}_3(\text{PO}_4)_2$  is separated from the soluble hypophosphite of barium by filtration, after which the addition of dilute sulphuric acid precipitates the barium of the hypophosphite of barium, leaving hydrated hypophosphorous acid in solution. The hypophosphites are all soluble in water.

### PHOSPHOROUS ACID (Hydrated).

#### *Hydric Phosphite.*

Symbol,  $\text{H}_3\text{PO}_3$ ; Equivalent, 82.

39.—When phosphorus is exposed to the action of the air, it undergoes a slow combustion, becoming converted into liquid phosphorous acid, the phosphorus uniting with oxygen and aqueous vapour from the atmosphere. The liquid acid when heated strongly undergoes decomposition, being resolved into hydrated phosphoric acid and phosphide of hydrogen gas.

The phosphites resemble the hypophosphites in their leading chemical properties.

### PHOSPHORIC ACID (anhydrous).

#### *Phosphoric Anhydride.*

Symbol,  $\text{P}_2\text{O}_5$ ; Equivalent, 142.

40.—PREPARATION.—If phosphorus be burned in dry air or oxygen gas, a white crystalline substance is produced, which is anhydrous phosphoric acid.

It combines with water forming hydrated phosphoric acid.

### PHOSPHORIC ACID. (Hydrated Tribasic.)

#### *Trihydric Phosphate.*

Symbol,  $\text{H}_3\text{PO}_4$ ; Equivalent, 98.

41. PREPARATION.—When phosphorus is added in small portions at a time to nitric acid, *hydric nitrate*, it is oxidized, and upon cautious evaporation this acid is obtained.

PROPERTIES:—A white crystalline solid, having an intensely acid taste. It unites with bases, forming a series of important salts, which may be divided into three classes, viz.,—one neutral tribasic phosphate, and two acid tribasic phosphates.

## EXAMPLES:—

Neutral tribasic phosphate of potassium <i>Tripotassic phosphate</i>	}	$K_3PO_4$
Neutral tribasic phosphate of calcium <i>Tricalcic phosphate.</i>		
(a) Acid tribasic phosphate of potassium <i>Hydrodipotassic phosphate.</i>	}	$H, K_2PO_4$
Acid tribasic phosphate of calcium <i>Hydrocalcic Phosphate.</i>		
(b) Acid tribasic phosphate of potassium <i>Dihydropotassic phosphate.</i>	}	$H_2K, PO_4$
Acid tribasic phosphate of calcium <i>Tetrahydro calcic phosphate.</i>		
		$H_4Ca(PO_4)_2$

TESTS.—Neutral solutions containing phosphoric acid give the following reactions:—

1. With chloride of barium, *baric chloride*, a white precipitate, which is soluble in acids.
2. With chloride of calcium, *calcic chloride*, a white precipitate, soluble in acetic and mineral acids.
3. With sulphate of magnesium, *magnesian sulphate*, and ammonia a white precipitate, soluble in acids.
4. With nitrate of silver, *argentic nitrate*, a yellow precipitate.

## PHOSPHORIC ACID (hydrated bibasic).

*Dihydric Diphosphate.*

Symbol,  $H_2P_2O_6$ ; Equivalent, 160.

42. PREPARATION.—When hydrated tribasic phosphoric acid is heated to about 213 degrees Centigrade it loses water, being converted into hydrated bibasic phosphoric acid.

Tribasic phosphate of sodium, *hydrodisodic phosphate*, when heated red hot, becomes changed into neutral bibasic phosphate of sodium.

PROPERTIES.—A thick sour liquid, it unites with the bases to form two classes of salts, neutral and acid bibasic phosphates.



TESTS.—Neutral solutions of bibasic phosphate of sodium give the following reactions :—

- 1.—With nitrate of silver, *argentic nitrate*, a white precipitate is produced.
- 2.—With chloride of barium, *baric chloride*, a white precipitate is produced, which is soluble in acids.

### PHOSPHORIC ACID (hydrated monobasic).

*Trihydric Triphosphate.*

Symbol,  $H_3P_3O_9$  ; Equivalent, 240.

43. PREPARATION.—When the snow white anhydrous phosphoric acid formed by burning phosphorus under a bell jar containing oxygen is dissolved in water, a mixture of hydrated monobasic phosphoric acid, and hydrated tribasic phosphoric acid is formed.

PROPERTIES.—It is an acid liquid and is distinguished from bibasic and tribasic phosphoric acids by its reaction with a solution of albumen, with which it produces a white precipitate.

With chloride of barium, *baric chloride*, or nitrate of silver, *argentic nitrate*, a white precipitate is also formed. It unites with bases, giving rise to the formation of salts called monobasic phosphates.

### PHOSPHIDE OF HYDROGEN.

Symbol,  $PH_3$  ; Equivalent, 34.

44.—PREPARATION.—This gas is generally prepared by boiling a solution of hydrate of potassium, *potassic hydrate*, with pieces of phosphorus. Care must be taken that the retort be completely filled with the solution of hydrate of potassium, and the neck of the retort immersed in water, otherwise an explosion may occur, the gas being spontaneously inflammable upon coming in contact with air (or oxygen). Hypophosphite and phosphate of potassium remain in solution in the retort with the excess of hydrate of potassium.

PROPERTIES.—A colourless gas, having a smell resembling garlic, and possessing the remarkable property of spontaneous inflammability upon coming in contact with the air. M. Paul

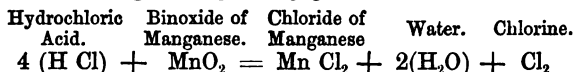
Thénard states that the spontaneous combustibility of the gas arises from the presence of a vapour of liquid phosphide of hydrogen,  $\text{PH}_2$ . It is decomposed by the action of sun light into a solid phosphide of hydrogen, which deposits on the sides of the gas jar, and a gaseous phosphide of hydrogen which is not spontaneously inflammable.

### CHLORINE.

Symbol, Cl ; Equivalent, 35·46, Volume 1.

45.—This element exists abundantly in nature, in combination with sodium as common salt, chloride of sodium, *sodic chloride*.

PREPARATION.—The gas can be prepared by the application of a gentle heat to a mixture of hydrochloric acid, *hydric chloride*, and binoxide of manganese, *manganic peroxide*; chloride of manganese, *manganous chloride*, and water remain in the retort, chlorine gas being disengaged, thus :—



PROPERTIES.—A greenish yellow coloured gas, irrespirable, having a suffocating odour, soluble in water. It is a heavy gas, 100 cubic inches weighing 76·8 grains, and is a most efficient disinfectant; it supports some kinds of combustion. The moist gas possesses great bleaching powers, destroying most vegetable colouring matters; the dry gas, however, does not possess this property.

It is extensively employed as a bleaching agent for linen and cotton goods. Bleaching powder or hypochlorite of calcium, *calcic hypochlorite*, is principally used as the source of chlorine for bleaching purposes. The commercial value of bleaching powder may be determined by the process described under chlorimetry. Chlorine unites with oxygen forming acids, with hydrogen forming hydrochloric acid, *hydric chloride*, and with bases to form chlorides.

### CHLORIMETRY.

46.—Chlorimetry is the process of determining the percentage by weight of chlorine, which is liberated from a sample

of bleaching powder, chloride of lime, &c., by the action of dilute hydrochloric or sulphuric acids.

Of the numerous methods which have been employed for this purpose, that which the author has found to have obtained the preference in our bleach works and manufactories is based upon the property which chlorine possesses of converting ferrous into ferric salts. This is easily discovered by means of a solution of red prussiate of potassium, *potassic ferri-cyanide*, which ceases to produce a blue colour with the iron solution as soon as the last trace of ferrous is converted into ferric salt.

The process consists in weighing 78.1 grains of pure crystallised protosulphate of iron, *ferrous sulphate*, dissolving it in about two ounces of water, and strongly acidulating with hydrochloric acid, *hydric chloride*. This solution requires 10 grains of chlorine to convert the 78.1 grains of ferrous salt into the ferric condition. 50 grains of the sample of bleaching powder under examination are weighed, ground well in a mortar with about one and a-half ounces of water, and the mixture poured into an alkalimeter; the alkalimeter to be filled up with water to 0 degrees with the washings of the mortar, and the whole well agitated.

The solution is then poured from the alkalimeter into the solution of ferrous sulphate (a few drops at a time), until the latter is completely converted into the ferric state, which is known by the reaction of a drop of the solution of iron with a drop of red prussiate of potassium. At the point at which it ceases to give Prussian blue with red prussiate of potassium, the number of measures poured from the alkalimeter must be carefully noted. The greater the number of measures used the less per centage of chlorine contained in the sample.

Supposing 65 measures have been used to yield 10 grains of chlorine, necessary for the conversion of the ferrous sulphate, the 65 measures only contain 32.5 grains of bleaching powder for 50 grains of the sample were dissolved in 100 measures of the alkalimeter, then:—

$$\text{As } 32.5 : 10 :: 100 : x = \left. \vphantom{\begin{array}{l} 32.5 \\ 10 \\ 100 \\ x \end{array}} \right\} \begin{array}{l} 80.76 \text{ per cent. of chlorine} \\ \text{in the sample.} \end{array}$$

Good commercial bleaching powder contains from 35 to 36 per cent. of chlorine by weight.

A solution of bleaching powder is called "Chemic" by the trade.

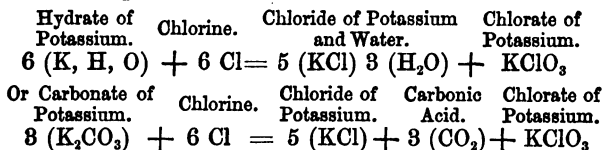
### CHLORIC ACID (Hydrated).

#### *Hydric Chlorate.*

Symbol,  $\text{HClO}_3$ ; Equivalent, 84.46.

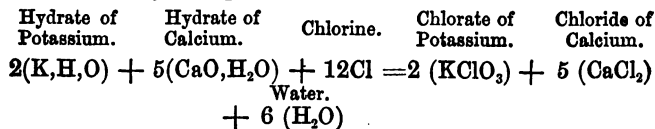
47.—PREPARATION.—METHOD I.—If chlorate of potassium, *potassic chlorate*, be decomposed by hydrofluosilicic acid, *hydric hydrofluosilicate*, insoluble hydrofluosilicate of potassium is precipitated, and upon filtration hydrated chloric acid is obtained.

METHOD II.—The acid may also be obtained from chlorate of barium, *baric chlorate*, by the action of dilute sulphuric acid, *hydric sulphate*; the barium is precipitated as a white insoluble sulphate, the acid remaining in solution. Chloric acid, in combination with potassium is formed when chlorine gas is passed through hot solutions of hydrate or carbonate of potassium, thus:—

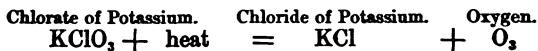


The solution upon evaporation yields crystals of chlorate of potassium, the chloride of potassium remaining in solution in the mother liquid.

A great saving of expense in the manufacture of chlorate of potassium has been effected within the last few years, by the addition of hydrate of calcium, *calcic hydrate*, to the hydrate of potassium, chloride of calcium, *calcic chloride*, being produced in the place of chloride of potassium, *potassic chloride*. The reaction of the chlorine upon the hydrates of calcium and potassium may be expressed, thus:—



**PROPERTIES.**—A dense acid liquor, destitute of any bleaching action upon colours. Unites with the bases forming salts, called chlorates, which undergo decomposition by heat into chlorides, with the liberation of oxygen gas, thus :—



**Tests.**—Solutions of the soluble chlorates do not produce any precipitate with the nitrates of silver or barium.

Most chlorates deflagrate when heated on charcoal.

### PERCHLORIC ACID (Hydrated).

*Hydric Perchlorate.*

Symbol,  $\text{HClO}_4$ ; Equivalent, 100.46.

**48.—PREPARATION.**—This acid, in combination with potassium, is obtained when chlorate of potassium, *potassic chlorate*, is cautiously acted upon by hot nitric acid, *hydric nitrate*, chlorine and oxygen gases are liberated, and a mixture of perchlorate and nitrate of potassium remain in the flask; upon evaporation and subsequent crystallization, perchlorate of potassium, *potassic perchlorate*, which is difficultly soluble in water, is obtained leaving nitrate of potassium, *potassic nitrate*, in solution. The hydrated perchloric acid distils over into the receiver, when a mixture of perchlorate of potassium and sulphuric acid are heated, sulphate of potassium remaining in the retort—

**PROPERTIES.**—A colourless acid liquid, highly explosive, exploding with great violence when brought into contact with alcohol, ether, &c. The acid is prone to spontaneous decomposition. It unites with the bases forming perchlorates.

### HYPOCHLORIC ACID.

*Hypochloric Anhydride.*

Symbol,  $\text{Cl}_2\text{O}$ ; Equivalent, 134.92.

**49.—PREPARATION.**—If a mixture of chlorate of potassium and concentrated sulphuric acid be very cautiously heated, this gas is liberated.

**PROPERTIES.**—It is a greenish yellow coloured gas, having a powerful odour, highly explosive, exploding at a temperature of about 212 degrees Fahr.; great care must therefore be taken preparing this compound.

## CHLOROUS ACID.

*Chlorous Anhydride.*Symbol,  $\text{Cl}_2\text{O}_3$  ; Equivalent, 118.92.

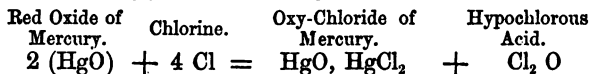
50. PREPARATION.—This acid is evolved as a gas when dilute nitric acid acts upon a mixture of chlorate of potassium, *potassic chlorate*, and arsenious or tartaric acid, assisted by the application of a gentle heat.

PROPERTIES.—A greenish yellow gas, resembling chlorine, is slightly soluble in water, bleaches vegetable colours, unites with the bases forming salts named chlorites.

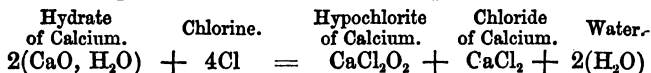
## HYPOCHLOROUS ACID.

*Hypochlorous Anhydride.*Symbol,  $\text{Cl}_2\text{O}$  ; Equivalent, 86.92.

51.—PREPARATION.—The acid is formed when chlorine acts upon red oxide of mercury, *mercuric oxide*, oxychloride of mercury and hypochlorous acid gas are formed, thus :—



It is also formed in combination with calcium or potassium when chlorine gas is passed through a solution of hydrate of calcium or potassium at the ordinary temperature, thus :—



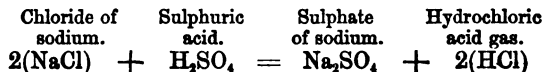
PROPERTIES.—A yellow gas, having an odour of chlorine, soluble in water, powerful bleaching agent ; the gas explodes violently when heated, unites with the bases forming salts called hypochlorites.

## HYDROCHLORIC ACID.

*Hydric Chloride.*Symbol,  $\text{HCl}$  ; Equivalent, 36.46.

52. PREPARATION.—This gas is prepared from common salt (chloride of sodium), by the action of sulphuric acid, *hydric*

*sulphate*, with the assistance of heat, sulphate of sodium, *sodic sulphate*, and hydrochloric acid gas are formed, thus :—



**PROPERTIES.**—A colourless powerfully acid gas, extremely soluble in water, forming with it the common liquid hydrochloric or muriatic acid of trade. Being a waste product of the manufacture of soda ash (carbonate of sodium), it is one of the cheapest and most important of acids, being largely consumed by bleachers, calico printers, &c. The liquid hydrochloric acid is colourless, fuming when exposed to the air, does not possess any bleaching properties. It forms with the bases a class of salts called chlorides, most of which are soluble in water.

**TESTS.**—Hydrochloric acid or any soluble chloride produces with a solution of nitrate of silver, *argentic nitrate*, a white precipitate of chloride of silver, *argentic chloride*, insoluble in nitric acid, *hydric nitrate*, but readily soluble in ammonia.

### BROMINE.

Symbol, Br ; Equivalent, 79.97 ; Volume, 1.

53. This element exists in nature in combination with magnesium, potassium, &c., as bromides.

**PREPARATION.**—The uncrystallizable mother liquid obtained from salt manufacture is treated with chlorine, which decomposes the bromides converting them into chlorides setting free bromine ; the whole is then well agitated with ether, which dissolves the bromine. The ethereal solution is mixed with hydrate of potassium, *potassic hydrate*, and heat applied ; ether and water distil off, bromide and bromate of potassium remaining in the retort. The compound salt is heated red hot, which decomposes the bromate of potassium, *potassic bromate*, changing it to bromide ; the bromide of potassium, *potassic bromide*, is distilled with binoxide of manganese, *manganic peroxide*, and sulphuric acid, *hydric sulphate* ; bromine volatilizes and may be condensed in a receiver.

**PROPERTIES.**—A dark liquid evolving orange yellow fumes when exposed to the air. It has an offensive and suffocating odour, its aqueous solutions bleach vegetable colours. It com-

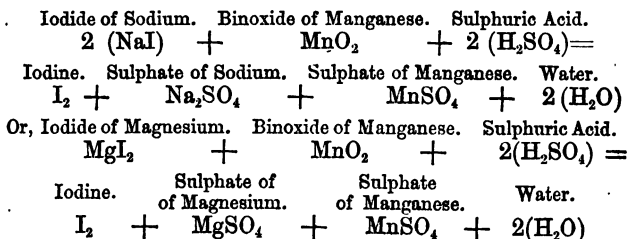
bines with oxygen, forming several acids of which bromic acid is the most important, and with hydrogen forming hydro-bromic acid, *hydric bromide*, also with the bases to form bromides, which resemble in their crystalline form the corresponding iodides and chlorides.

TESTS.—Solutions containing hydro-bromic acid or soluble bromides, produce a yellowish white precipitate with nitrate of silver, *argentic nitrate*, which is insoluble in nitric acid, *hydric nitrate*, and difficultly soluble in ammonia. With nitric acid and starch paste a yellow colour is produced.

### IODINE.

Symbol, I ; Equivalent, 126·88 ; Volume, 1.

54.—PREPARATION.—This element is obtained from sea weeds, which are first burned to destroy the organic matter ; the resulting ashes which are called “kelp,” are treated with water to dissolve the soluble salts, consisting principally of carbonate, chloride, iodide, &c. of sodium, potassium, and magnesium. The liquor is evaporated and allowed to crystallize ; crystals of carbonate of sodium with chlorides of potassium and sodium, &c., are deposited, leaving impure iodide of sodium and magnesium in the mother liquid. This liquor is distilled in a retort with binoxide of manganese, *manganic peroxide*, and sulphuric acid, *hydric sulphate*, when violet fumes of iodine pass over into the receiver and condense into the solid form. The following is the reaction which takes place in the retort :—



PROPERTIES.—A black crystalline solid substance, with a metallic lustre resembling black lead, stains the skin yellow, when heated it volatilizes as a beautiful violet vapour. It is



only slightly soluble in water, but is readily so in alcohol. A solution containing the smallest trace of free iodine produces a dark blue colour with starch paste; this characteristic reaction readily distinguishes it from bromine. It combines with oxygen, forming acids resembling those of bromine and chlorine; with hydrogen it forms hydriodic acid, *hydric iodide*, and enters into combination with the bases forming iodides.

### HYDRIODIC ACID (Gas).

Symbol, HI; Equivalent, 127.88.

55. PREPARATION.—If a small flask be filled with a mixture of powdered glass, small pieces of phosphorus and iodine, the whole moistened with water, and heat cautiously applied, this gas will be evolved.

PROPERTIES.—A colourless acid gas resembling hydrochloric acid, fuming in contact with air and soluble in water.

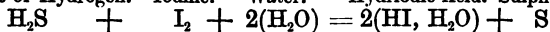
### HYDRIODIC ACID (Liquid).

*Hydric Iodide.*

Symbol HI, H<sub>2</sub>O

56. PREPARATION.—When a stream of sulphide of hydrogen gas is passed for some hours through water containing powdered iodine in mechanical suspension, hydrated hydriodic acid is formed, sulphur being precipitated, thus:—

Sulphide of Hydrogen. Iodine. Water. Hydriodic Acid. Sulphur.



After the whole of the iodine is decomposed by the sulphide of hydrogen gas, the solution is boiled to expel any excess of gas and filtered.

PROPERTIES.—A colourless, strongly acid liquid, uniting with the bases, forming a class of salts called iodides.

TESTS.—Hydrated hydriodic acid or solutions of iodides, produce with nitrate of silver a yellow precipitate, insoluble in nitric acid, *hydric nitrate*, and difficultly soluble in ammonia.

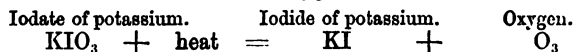
With nitric acid and starch paste, dark blue iodide of starch is formed.

## IODIC ACID. (hydrated.)

*Hydric Iodate.*Symbol,  $\text{HIO}_3$ ; Equivalent, 175.88.

57. PREPARATION.—This acid is usually prepared by boiling in a flask nitric acid with iodine for some hours until the iodine is dissolved. The excess of nitric acid is then driven off by evaporating the solution almost to dryness.

PROPERTIES.—It crystallizes in white crystals, possessing acid properties, and unites with the bases forming iodates, which resemble the chlorates; the salts are decomposed at a red heat into iodides and free oxygen, thus:—



## PERIODIC ACID.

*Hydric Periodate.*Symbol,  $\text{HIO}_4$ ; Equivalent, 191.88.

58. PREPARATION.—By passing chlorine gas through a solution of iodate of sodium, *sodic iodate*, with hydrate of sodium, *sodic hydrate*, two salts are formed, chloride of sodium, *sodic chloride*, and a double salt consisting of periodate of sodium, *sodic periodate*, and hydrate of sodium; the latter compound, being difficultly soluble in water, is precipitated. It is converted into the silver salt, which is lastly decomposed by water into free acid and insoluble basic periodate of silver, *argentic periodate*.

PROPERTIES.—A crystallizable acid combining with the bases to form salts called periodates.

## IODIDE OF NITROGEN.

Symbol,  $\text{NHI}_2$ , or  $\text{NI}_3 + \text{NH}_3$ .

59. PREPARATION.—Iodine is added to strong liquid ammonia, *ammonic hydrate*; and after the elapse of a few hours the insoluble iodide of nitrogen formed is collected upon a filter.

PROPERTIES.—A dark brown powder, and exploding when dry with the slightest friction.

## FLUORINE.

Symbol, F ; Equivalent, 19 ; Volume, 1.

60. Fluorine exists in nature in combination with calcium as fluor-spar, *calcic fluoride*.

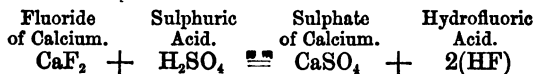
It is a gaseous element which has not yet been successfully isolated. It combines with the bases to form fluorides, and with hydrogen to form hydrofluoric acid, *hydric fluoride*.

## HYDROFLUORIC ACID (Hydrated).

*Hydric Fluoride*.

Symbol, (HF + H<sub>2</sub>O.)

61.—When powdered fluoride of calcium is distilled with sulphuric acid, *hydric sulphate*, in a leaden retort, and a little water in the receiver, hydrated hydrofluoric acid is obtained, sulphate of calcium, *calcic sulphate*, remaining in the retort, thus :—



PROPERTIES.—A corrosive acid liquid, evolving white fumes when exposed to the air, and entering into combination with the bases forming fluorides. The most characteristic property which this acid possesses is that of etching glass, entering into combination with its silica, dissolving it, forming ter-fluoride of silicium.

## SILICIUM.

Symbol, Si ; Equivalent, 28 ; Volume, 1.

62.—Silicium or silicon, occurs in nature in great abundance, in combination with oxygen as silicic acid, sand, quartz, flint, &c.

PREPARATION.—If the double fluoride of silicium and potassium be heated with potassium, and the mixture when cold treated with water, a brownish insoluble powder is obtained, which is silicium.

PROPERTIES.—The silicium obtained by the above process is of a dark brown colour ; when heated in the air, it ignites uniting with oxygen forming silica. There are several allo-

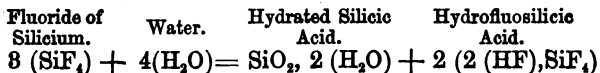
tropic conditions of silicium. It combines with oxygen to form silicic acid and with hydrogen to form hydride of silicium.

### SILICIC ACID (Silica).

Symbol,  $\text{SiO}_2$ ; Equivalent, 60.

63.—This acid exists in a pure crystalline state, as Rock Crystal.

PREPARATION.—If fluoride of silicium gas be passed through water, it is decomposed into hydrated silicic acid which is precipitated, and hydrofluosilicic acid remains in solution, thus:—



The gelatinous precipitate of hydrated silicic acid, *hydric silicate*, is collected on a filter, washed with water, dried and heated red hot, anhydrous silicic acid or silica is obtained.

PROPERTIES.—A white powder, very difficultly fusible, insoluble in acids and alkalis, with the exception of hydrofluoric acid, which readily dissolves it.

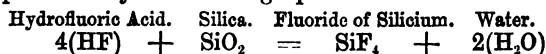
Hydrated silicic acid is soluble in acids and alkalis. When strongly heated it loses water and becomes converted into insoluble anhydrous silicic acid.

### FLUORIDE OF SILICIUM.

*Silicic Fluoride.*

Symbol,  $\text{SiF}_4$ ; Equivalent, 104.

64. PREPARATION.—This gas is prepared by heating a mixture of fluoride of calcium, *calcic fluoride*, powdered glass, and sulphuric acid, *hydric sulphate*. The hydrofluoric acid which is first generated immediately enters into combination with the silica of the powdered glass, forming fluoride of silicium. The reaction of hydrofluoric acid upon silica may be represented by the following equation:—



PROPERTIES.—A colourless gas forming white fumes with moist air; it is decomposed by water into hydrated silicic acid and hydrofluosilicic acid—par. 63.

65. Hydrofluosilicic acid, *hydric hydrofluosilicate*, is a valuable reagent in the laboratory, and is employed for the quantitative separation of barium from strontium and calcium.

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### BORON.

Symbol, B ; Equivalent, 11·04 ; Volume, 1.

66. This element occurs in nature in combination with oxygen and sodium as tincal, boracic acid, and borax.

PREPARATION.—Boron may be prepared from the double fluoride of boron and potassium by the action of potassium and heat. The mass, when cold, is treated with water, which dissolves the soluble fluoride of potassium, *potassic fluoride*, leaving boron as an insoluble powder, which may be collected on a filter, washed with water, and dried.

PROPERTIES.—The boron prepared by the above process, when heated red hot in contact with air, burns forming boracic acid  $B_2O_3$ .

Several modifications of boron have been discovered, one of which is crystalline and almost infusible by heat.

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### BORACIC ACID (Hydrated).

#### *Hydric Borate.*

Symbol,  $B_2O_3 + 3(H_2O)$

67. This acid is formed when boron is dissolved in nitric acid, *hydric nitrate*, and the solution evaporated to dryness to expel any excess of nitric acid present.

PROPERTIES.—A colourless crystallizable feeble acid, soluble in water ; when heated red hot it loses water and becomes changed into the anhydrous condition, which is a glassy looking solid substance, having the property of dissolving most of the metallic oxides at a red heat. Alcoholic solutions of boracic acid burn with a green flame. With the bases it forms salts named borates.

Biborate of sodium or borax is the most important salt of boracic acid.

**THE**  
**METALLIC ELEMENTS.**

# THE METALLIC ELEMENTS.

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## CHAPTER II.

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### THE ALKALIS.

#### POTASSIUM.

Symbol, K ; Equivalent, 39.11.

68.—This element exists in nature as nitrate, chloride, silicate, tartrate, and sulphate of potassium.

PREPARATION.—Argol or crude acid tartrate of potassium, *hydropotassic tartrate*, is strongly heated ; it undergoes decomposition being converted into carbonate of potassium, *potassic carbonate*, and free carbon. The whole is mixed with roughly powdered charcoal, introduced into an iron or fire clay retort, and heated almost white hot ; the receiver must be half filled with benzol, and surrounded with cold water. Impure potassium distils over into the receiver, and carbonic oxide gas is evolved. By re-distillation pure potassium is obtained.

PROPERTIES.—A silvery white metal, easily cut with a knife at the ordinary temperature, melts at 186 degrees Fahr., its specific gravity is only 0.865 ; when exposed to the air it immediately enters into combination with oxygen, forming oxide of potassium, *potassic oxide*, it is therefore preserved in coal naphtha or benzol, a liquid free from oxygen. It decomposes water with the liberation of hydrogen gas, and formation of hydrate of potassium, *potassic hydrate*, thus :—



When thrown on water in contact with air, the liberated hydrogen gas is set on fire by the heat generated from the chemical action, a portion of the potassium is also volatilized, and ignites burning with a violet flame. It unites with acids forming a series of important salts.

### OXIDE OF POTASSIUM.

#### *Potassic oxide.*

Symbol,  $K_2O$  ; Equivalent, 94.22.

69. PREPARATION.—This compound is formed when potassium is burned in dry air.

PROPERTIES.—A white alkaline substance, uniting with water, producing heat and forming hydrate of potassium, *potassic hydrate*.

TESTS.—Neutral solutions of potassium salts give the following reactions with the reagents :—

1. A solution of tartaric acid produces a white crystalline precipitate of acid, tartrate of potassium, *hydro potassic tartrate*.
2. A solution of bichloride of platinum produces a yellow crystalline precipitate of chloride of potassium and platinum.

Note.—The formation of the above precipitates, is accelerated by agitation.

8. Blowpipe flame, colour, violet.

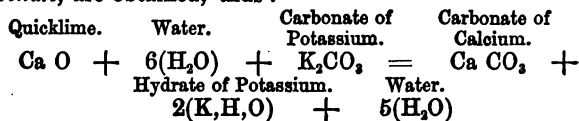
### HYDRATE OF POTASSIUM.

#### *Potassic hydrate.*

Symbol,  $K, H, O$  ; Equivalent, 56.11.

70. This compound is generally called caustic potash.

PREPARATION.—By boiling for about one hour a moderate dilute solution of carbonate of potassium, *potassic carbonate*, with a weight of quicklime, *calcic oxide*, equal to the quantity of dry carbonate of potassium contained in solution ; hydrate of potassium and a precipitate of carbonate of calcium, *calcic carbonate*, are obtained, thus :—





The clear liquor is then decanted and evaporated in a silver bowl until it solidifies upon cooling.

**PROPERTIES.**—A white deliquescent solid, extremely soluble in water; this solution is powerfully alkaline, immediately turning red litmus paper blue and yellow turmeric paper reddish brown. It is a most useful reagent in the laboratory, combining with and completely neutralizing all acids forming a numerous class of most important salts. Hydrate of potassium cannot be rendered anhydrous by the application of the strongest heat. It is extensively used in the manufacture of soft soap.

## CARBONATE OF POTASSIUM.

### *Potassic carbonate.*

Symbol,  $K_2CO_3$ ; Equivalent, 138.22.

71. This compound is commonly called pearl ashes, and is extensively used in the arts and manufactures.

**PREPARATION.**—Commercial potashes, consisting principally of carbonate, with chloride, sulphate, and silicate of potassium, &c., is obtained by lixiviating the ashes of burned wood, and evaporating the solution to dryness. Pure carbonate is obtained from the above impure compound, in the following manner:—Potashes are treated with water, the solution filtered, evaporated, and allowed to cool, when the carbonate of potassium crystallizes in minute crystals; these are collected upon strainers, the mother liquor, which drains through, containing most of the impurities. The carbonate of potassium thus obtained is purified by re-crystallization and lastly dried.

**PROPERTIES.**—A white alkaline salt, soluble in water and insoluble in alcohol.

## BICARBONATE OF POTASSIUM.

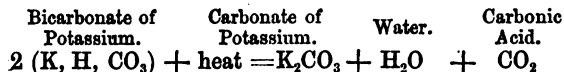
### *Hydropotassic carbonate.*

Symbol,  $KH_2CO_3$ ; Equivalent, 100.11.

72. **PREPARATION.**—This salt is formed when carbonic acid gas is passed through a solution of carbonate of potassium,

*potassic carbonate.* Upon allowing it to stand some time crystals of bicarbonate of potassium are obtained, which may be collected upon a filter, drained, and then dried.

PROPERTIES.—A white crystalline salt, almost neutral to test papers, rather difficultly soluble in water. A solution of this salt is decomposed by heat into carbonate of potassium, *potassic carbonate*, water, and carbonic acid gas thus :—



### NITRATE OF POTASSIUM.

#### *Potassic Nitrate.*

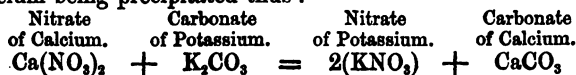
Symbol, KNO<sub>3</sub>; Equivalent, 101·11.

73.—This salt occurs native in Hindostan, and is commonly called saltpetre or nitre.

PREPARATION.—Impure East Indian saltpetre, consisting principally of nitrate of potassium, *potassic nitrate*, with sulphate and chloride of potassium is dissolved in water, a small quantity of carbonate of potassium, *potassic carbonate*, added, and allowed to deposit the insoluble impurities, then evaporated and crystallized. The crystals of impure nitrate of potassium obtained, are purified by solution and recrystallization.

Nitrate of potassium can also be obtained by the process of “nitrication,” which consists in mixing animal refuse, urine, &c., with old mortar (carbonate of calcium, earth, &c.), and exposing the whole to the action of the air for some weeks. The heap is turned over from time to time, to assist the oxidation of the ammonia (of the organic matter) into nitric acid and water, the nitric acid formed, uniting with the calcium of the carbonate of calcium, *calcic carbonate*, forming nitrate of calcium.

This salt is dissolved out by treating the compound with water, and decomposed by means of carbonate of potassium, *potassic carbonate*, into nitrate of potassium, and carbonate of calcium being precipitated thus :—



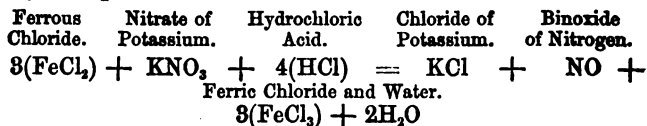
The clear solution, upon evaporation and subsequent crystallization, yields crystals of nitrate of potassium.

PROPERTIES.—A white crystalline neutral salt, soluble in water.

74. Gunpowder.—This compound contains about 75 per cent. by weight of nitrate of potassium, with 15 per cent. of charcoal, and 10 per cent. of sulphur mechanically mixed. When fired nitrogen gas is liberated, and carbonic acid gas and sulphide of potassium are formed.

PROCESS FOR THE ESTIMATION OF THE PER CENTAGE OF PURE NITRATE OF POTASSIUM, CONTAINED IN A SAMPLE OF COMMERCIAL NITRE OR SALTPETRE.

75. This process is based upon the property which nitrate of potassium, *potassic nitrate*, possesses of converting the ferrous into ferric salts when heated with an excess of hydrochloric acid, *hydric chloride*. The reaction which takes place may be expressed thus:—



One equivalent, 101.11 grains, of nitrate of potassium is equal to 168 grains or three equivalents of metallic iron in solution, and 100 grains of nitrate of potassium are therefore equivalent to 166.15 grains of metallic iron.

A standard solution of acid chromate of potassium, *potassic dichromate*, must be prepared in order to determine the amount of ferrous chloride which remains unaltered, from which data the amount of ferrous chloride converted by the nitrate of potassium into the ferric state can be calculated. If 88.8 grains of pure acid chromate of potassium are dissolved in 10 alkalimeters (10,000 grains) of water: 100 measures of this standard solution will be capable of converting 10 grains of iron from the ferrous to the ferric state. 41.58 grains of thin iron wire are heated in a flask with three ounces of hydro-

chloric acid, *hydric chloride*, until the complete solution of the iron is effected; 25 grains of the sample of the nitre under examination are then added and heat applied until the solution which at first assumes a black colour, becomes of a clear reddish amber colour; it is lastly diluted with about three ounces of water.

If a drop of the solution when tested with ferricyanide of potassium, *potassic ferricyanide*, gives a blue colour, then the standard solution of acid chromate of potassium, *potassic dichromate*, described above, is added cautiously from an alkali-meter, until a drop of the solution ceases to give a blue colour with ferricyanide of potassium. The operation is then finished, and the number of measures of the standard solution employed are to be noted.

**EXAMPLE.**—Twenty-five grains of a sample of saltpetre were added to the hot solution of 41·58 grains of iron in hydrochloric acid. After the decomposition of the nitrate of potassium and the dilution of the solution with water, 85 measures of the standard acid chromate of potassium solution were added to effect the conversion of the unaltered ferrous into ferric chloride.

Thirty-five measures of the standard chrome solution being equivalent to 8·5 grains of metallic iron, this amount must be subtracted from the number of grains weighed, viz :—41·58, which leaves 38·08 grains, the amount of iron changed into ferric salt by the 25 grains of saltpetre taken.

As 166·15 grains of iron are equal to 100 grains of pure nitrate of potassium, so is 38·08 grains of iron equivalent to 22·88 grains of nitrate of potassium contained in the 25 grains taken, and this quotient multiplied by 4, will give the per centage of pure nitrate of potassium contained in the sample under examination :—

$$\text{As } 166\cdot15 : 100 :: 38\cdot08 : x = 22\cdot88$$

$$\begin{array}{r} 3808\cdot00 \\ 38280 \\ \hline 48000 \\ 38280 \\ \hline \end{array}$$

147700  
182920

147800  
182920

14880

$22.88 \times 4 = 91.52 =$  per centage of nitrate of potassium contained in the sample.

76.—Commercial nitrate of sodium, or Chili saltpetre, may be tested by the above process. One equivalent, 85 grains of pure nitrate of sodium being necessary for the conversion of three equivalents 168 grains of metallic iron; 100 grains of nitrate of sodium will therefore require 197.63 grains of metallic iron.

49.40 grains of thin iron wire are dissolved in hydrochloric acid, and 25 grains of the sample of Chili saltpetre added. After boiling for some time, the solution is diluted with water, and the standard chrome added in the manner before described.

EXAMPLE.—49.40 grains of iron and 25 grains of Chili saltpetre, took 80 measures of chrome solution, then

49.40 — 3.0 = 46.40 = grains of iron oxidized by the Chili saltpetre,

As 197.63 : 100 :: 46.40 : x = 23.47  
46.40

4640.00  
89526

68740  
59289

94510  
79052

154580  
138341

16239

$28.47 \times 4 = 98.88 =$  the per centage of nitrate of sodium contained in the sample.

---

### SULPHATE OF POTASSIUM.

#### *Potassic Sulphate.*

Symbol,  $K_2SO_4$ ; Equivalent, 174.22.

77. PREPARATION.—This salt is formed when a solution of carbonate of potassium, *potassic carbonate*, is neutralized with sulphuric acid, *hydric sulphate*, and the solution allowed to crystallize.

PROPERTIES.—A white crystalline neutral salt, soluble in water.

---

### BISULPHATE OF POTASSIUM.

#### *Hydropotassic Sulphate.*

Symbol,  $K, H, SO_4 + Aq$  Equivalent, 154.11.

78. PREPARATION.—This salt is prepared by neutralizing a measured quantity of dilute sulphuric acid with carbonate of potassium, and then adding an amount of acid equal to the quantity neutralized, evaporating the solution, and leaving it to crystallize.

PROPERTIES.—A white crystalline acid salt, soluble in water.

---

### CHLORATE OF POTASSIUM.

#### *Potassic Chlorate.*

Symbol,  $KClO_3$ ; Equivalent, 122.57.

79. The preparation of this salt has already been described under the subject of chloric acid, par. 47.

PROPERTIES.—A white crystalline neutral salt. This salt deflagrates when heated upon charcoal, also explodes by friction when rubbed with sulphur, phosphorus, &c. It is principally used in the manufacture of lucifer matches and for the preparation of oxygen gas.

## PERCHLORATE OF POTASSIUM.

*Potassic Perchlorate.*

Symbol,  $\text{KClO}_4$ ; Equivalent, 138.57.

80. The preparation of this salt has already been described under the head of perchloric acid, par. 48.

PROPERTIES.—A white crystalline salt, almost insoluble in cold water. The salt is decomposed by heat, being converted into chloride of potassium, *potassic chloride*, with the liberation of oxygen gas.

## SULPHIDES OF POTASSIUM.

81. Protosulphide of potassium  $\text{K}_2\text{S}$ , *potassic sulphide*.  
 Tersulphide of potassium  $\text{K}_2\text{S}_3$ , “ *tersulphide*  
 Pentasulphide of potassium  $\text{K}_2\text{S}_5$ , “ *pentasulphide*

## PROTOSULPHIDE OF POTASSIUM.

*Potassic Sulphide.*

82. PREPARATION.—This sulphide is prepared by taking a strong solution of hydrate of potassium, *potassic hydrate*, and passing sulphide of hydrogen gas through one half, and after saturation adding the other half; the mixture is then evaporated to dryness and fused at a red heat.

PROPERTIES.—A reddish coloured mass, readily soluble in water; the solution is powerfully alkaline, is decomposed by acids with the generation of sulphide of hydrogen gas.

## TER- AND PENTA-SULPHIDES OF POTASSIUM.

*Potassic Ter-and Penta-Sulphides.*

83.—These higher sulphides are obtained by heating protosulphide of potassium with different equivalent proportions of sulphur. When hydrate or carbonate of potassium is fused with half its weight of sulphur, tersulphide of potassium and hyposulphite of potassium are produced.

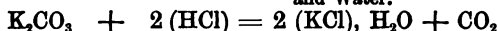
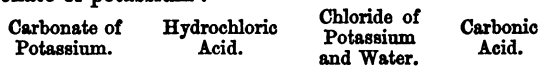
The aqueous solutions of these sulphides are decomposed by acids with the formation of a precipitate of sulphur and liberation of sulphide of hydrogen.

## CHLORIDE OF POTASSIUM.

### *Potassic Chloride.*

Symbol, KCl; Equivalent, 74.57.

84.—This salt is formed when carbonate of potassium, *potassic carbonate*, is dissolved in water, and hydrochloric acid carefully added until complete neutralization is effected. The solution is then allowed to crystallize. The following equation will explain the reaction of the hydrochloric acid upon the carbonate of potassium :—



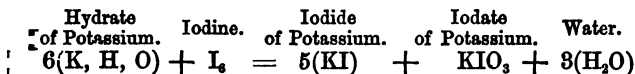
PROPERTIES.—A white crystalline neutral salt, resembling common salt.

## IODIDE OF POTASSIUM.

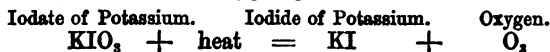
### *Potassic Iodide.*

Symbol, KI ; Equivalent, 165.99.

85. PREPARATION.—METHOD I.—If iodine be dissolved in a strong solution of hydrate of potassium, iodide and iodate of potassium are formed, thus :—



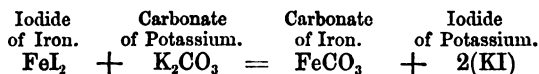
The solution is evaporated to dryness, and heated almost red hot ; the iodate is then decomposed, being changed into iodide of potassium and oxygen gas, thus :—



Upon cooling the mass is dissolved in water, filtered, and the salt allowed to crystallize.



**METHOD II.**—Iodide of potassium can also be prepared by the following process :—Iron filings, water, and iodine are placed in a flask ; when the solution has become colourless, the iron in solution will exist in the condition of protoiodide of iron, *ferrous iodide* ; the resulting clear liquor is decomposed with a solution of carbonate of potassium, the iron being precipitated as carbonate, and iodide of potassium remaining in solution, thus :—



The precipitate of carbonate of iron, *ferrous carbonate*, is separated by filtration ; and the filtrate upon evaporation yields crystals of iodide of potassium.

**PROPERTIES.**—A white crystalline salt, extremely soluble in water ; soluble in alcohol. A solution of this salt is employed as a reagent in the laboratory, and is extensively used in photography and in medicine.

## BROMIDE OF POTASSIUM.

*Potassic Bromide.*

Symbol, KBr ; Equivalent, 119·08.

86. This salt may be prepared by either of the processes described under the head of iodide of potassium, substituting bromine for iodine.

**PROPERTIES.**—A white crystalline salt, resembling the iodide, soluble in water and alcohol. It is employed in photography.

## YELLOW CHROMATE OF POTASSIUM.

*Potassic chromate.*

Symbol,  $\text{K}_2\text{CrO}_4$  ; Equivalent, 195·72.

87. **PREPARATION.**—This salt is manufactured from native-chrome iron ore, a compound of protoxide of iron with sesquioxide of chromium. From numerous analyses of this mineral

the author has found the per centage of sesquioxide of chromium to range from 33 to 54 per cent.

The chrome iron stone is first ground to the condition of a powder, then mixed with potashes (impure carbonate of potassium), and heated for some hours in a reverberatory furnace. The sesquioxide of chromium is oxidized, and changed into chromic acid, which unites with the potassium of the potashes, forming chromate of potassium. The crude product when cold is lixiviated, and the clear yellow solution upon evaporation deposits yellow chromate of potassium in crystals.

PROPERTIES.—A yellow crystalline neutral salt, soluble in water. A solution of the salt is used in the laboratory as a reagent, and by calico printers, dyers, and colour manufacturers.

### RED CHROMATE OF POTASSIUM.

*Potassic Dichromate.*

Symbol,  $K_2Cr_2O_7$ ; Equivalent, 297.22.

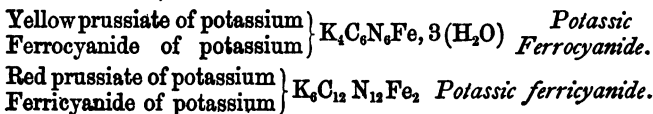
88. PREPARATION.—When two equivalents of yellow chromate of potassium are treated with one equivalent of sulphuric acid, one equivalent of bichromate of potassium, and one equivalent of sulphate of potassium are formed, thus:—



Upon evaporation the salt crystallizes.

PROPERTIES—This beautiful red crystalline salt is soluble in water, the solution having an acid reaction to test paper. It is extensively employed by dyers, calico printers, and colour makers, for the preparation of dyes, pigments, paints, &c.; it is also a valuable reagent to the analyst.

### 89. YELLOW, AND RED PRUSSIATES OF POTASSIUM



## YELLOW PRUSSATE OF POTASSIUM.

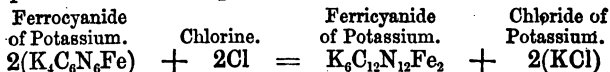
90.—PREPARATION.—By heating red hot in iron pots, nitro-genous animal matter, such as hoofs, wool, &c., with potashes, and treating the mass when cold with water, impure yellow prussiate of potassium is obtained in solution. Upon allowing the liquor to settle for a time, and then evaporating to the proper density, crystals of this salt are formed. By re-solution and crystallization, pure ferrocyanide of potassium is obtained. The formation of the salt may be explained in the following manner:—the nitrogen, and carbon of the organic matter, at a high temperature in the presence of potassium salts, unite forming cyanogen, which immediately enters into combination with the potassium forming cyanide of potassium, *potassic cyanide*, this salt upon solution reacts upon the iron, existing as oxide, and sulphide in the mass (and derived from the iron pots, and impurity of the potashes), with which it unites forming ferrocyanide of potassium.

PROPERTIES.—A yellow crystalline neutral salt, soluble in water. A solution of this salt is a valuable reagent in the laboratory for the detection of ferrous, and ferric salts. It is largely employed by dyers, calico printers, and colour makers, for the production of prussian blue dyes, and pigments.

## RED PRUSSATE OF POTASSIUM.

91. PREPARATION.—Chlorine gas is passed through a solution of yellow prussiate of potassium until a portion of the liquor, when tested with ferric chloride, ceases to produce a blue colouration. The solution is then filtered, evaporated, and allowed to cool, when ferricyanide of potassium is obtained in crystals.

The chemical reaction of the chlorine upon the ferrocyanide of potassium can be explained, thus:—



The salt may be purified by recrystallization.

PROPERTIES.—A ruby red crystalline salt, soluble in water. A solution of this salt is a valuable reagent for distinguishing

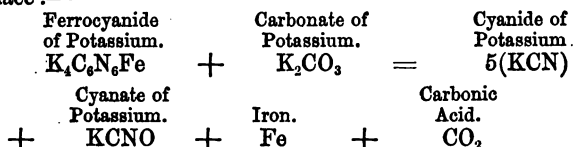
the ferrous from the ferric salts. It is extensively employed by dyers, calico printers, and colour makers.

## CYANIDE OF POTASSIUM.

### *Potassic Cyanide.*

Symbol, KCN ; Equivalent, 65·11.

92. PREPARATION.—Commercial cyanide of potassium is prepared by heating red hot in a crucible a mixture of eight parts by weight of ferrocyanide of potassium, and three parts of carbonate of potassium. The following reaction takes place :—



It is then taken from the fire, allowed to stand a few minutes for the iron to deposit at the bottom of the crucible, and the clear fluid (cyanide of potassium) poured off.

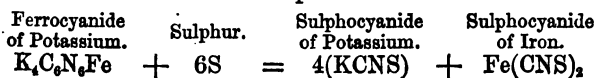
PROPERTIES.—A white salt, very soluble in water ; the solution has an alkaline reaction to test papers, and is extremely poisonous. This salt is extensively used by photographers, and manufacturers of electro-plate goods.

## SULPHOCYANIDE OF POTASSIUM.

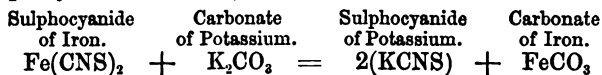
### *Potassic Sulphocyanide.*

Symbol, KCNS ; Equivalent, 97·11.

93. PREPARATION.—Finely powdered ferrocyanide of potassium is mixed with half its weight of sulphur, and the whole heated to fusion for some time ; the following equation will show the reaction which takes place :—

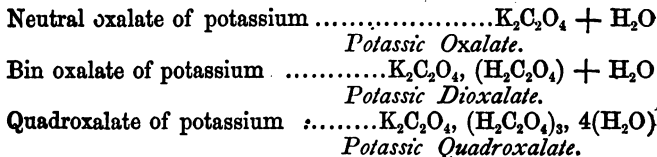


After the mass has been allowed to cool, it is treated with water, carbonate of potassium, *potassic carbonate*, added to decompose the sulphocyanide of iron, and the solution then filtered. The reaction of the carbonate of potassium upon the sulphocyanide of iron may be expressed thus :—



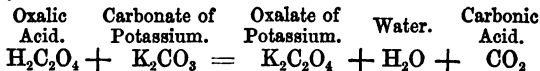
The solution, upon evaporation, deposits crystals of impure sulphocyanide of potassium, which may be purified by repeated solution, and crystallization.

#### 94. THE OXALATES OF POTASSIUM.



#### NEUTRAL OXALATE OF POTASSIUM.

95. PREPARATION.—This salt is prepared by neutralizing a hot solution of oxalic acid, with carbonate of potassium; oxalate of potassium is formed, and carbonic acid gas is evolved, thus :—



PROPERTIES.—A white crystalline neutral salt.

#### BINOXALATE OF POTASSIUM.

96.—PREPARATION.—This salt, which is commonly called salts of sorrel, is prepared by dividing a hot solution of oxalic

acid into two equal parts and neutralizing one part with carbonate of potassium, and then adding the other portion to it. The solution upon evaporation yields crystals of the salt.

PROPERTIES.—A white crystalline acid salt. A solution of the salt is employed to remove ink, and iron stains.

### QUADROXALATE OF POTASSIUM.

97. PREPARATION.—This salt is prepared by neutralizing one-fourth of a hot solution of oxalic acid with carbonate of potassium, and then adding the other three parts to it. The solution crystallizes upon cooling.

PROPERTIES.—A white crystalline powerfully acid salt. It is employed for the same purpose as the binoxalate.

The oxalates of potassium when heated red hot are decomposed into carbonates of potassium, without the liberation of free carbon; they, therefore, do not blacken when heated.

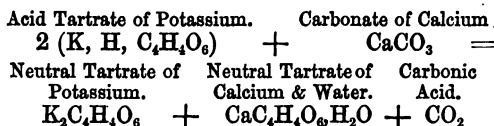
### 98. TARTRATES OF POTASSIUM.

Neutral tartrate of potassium .....  $K_2C_4H_4O_6 + 2(H_2O)$   
*Potassic Tartrate.*

Acid tartrate of potassium ..... *Hydropotassic Tartarate.*  
 $K, H, C_4H_4O_6$

### NEUTRAL TARTRATE OF POTASSIUM.

99. PREPARATION.—This salt is prepared by neutralizing a hot solution of argol (crude, acid, tartrate of potassium), by the addition of chalk (carbonate of calcium); neutral tartrates of potassium, and calcium are formed, thus :—



Upon filtration, and subsequent crystallization, the salt is deposited.

PROPERTIES.—A white crystalline neutral salt, readily soluble in water. When exposed to heat, it is decomposed, being converted into carbonate of potassium, with the formation of a black colour, due to particles of free carbon.

---

#### ACID TARTRATE OF POTASSIUM.

100. This is commonly called "cream of tartar."

PREPARATION.—"Argol," or "tartar," the deposit from grape juice, and wine, is impure acid tartrate of potassium. It is purified by solution in hot water, filtration through animal charcoal which destroys the colouring matter; evaporation, and crystallization.

PROPERTIES.—A white crystalline acid salt, almost insoluble in cold water. When heated, the salt blackens, being decomposed into free carbon, and carbonate of potassium.

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#### TARTRATE OF POTASSIUM AND ANTIMONY.

*Potassio-Antimonious Tartrate.*

Symbol, K, Sb,  $C_4H_4O_7 + 3 Aq.$

101. This salt is commonly called "tartar emetic."

PREPARATION.—The compound salt is prepared by adding tetroxide of antimony to a boiling hot solution of acid tartrate of potassium. After filtering the hot solution, crystals of tartrate of potassium and antimony are formed upon cooling.

PROPERTIES.—A white crystalline salt, difficultly soluble in water. It is principally employed in medicine, and is a poisonous salt.

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#### TARTRATE OF POTASSIUM AND SODIUM.

*Potassio Sodid Tartrate.*

Symbol, K, Na,  $C_4H_4O_6 + 4(H_2O).$

102. This compound is commonly called "Rochelle," or "Seignette salt."

**PREPARATION.**—The salt is prepared by neutralizing a hot solution of acid tartrate of potassium with carbonate of sodium ; tartrate of potassium, and sodium are formed, and carbonic acid gas evolved. The salt is deposited in crystals upon evaporation.

**PROPERTIES.**—A crystalline salt, soluble in water, effloresces slightly when exposed to the air. It possesses a mild, saline taste, and is employed in medicine.

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### SODIUM.

Symbol, Na ; Equivalent, 23.

103. This element exists in nature as chloride, silicate, nitrate, borate, carbonate, &c.

**PREPARATION.**—The metal is prepared from a mixture of carbonate of sodium, and powdered charcoal, with a little carbonate of calcium, the whole being heated white hot in an iron or fire-clay retort after the manner described under the head of potassium, par. 68.

**PROPERTIES.**—A silvery white metal resembling potassium in most of its physical, and chemical properties. It decomposes water, forming hydrate of sodium and hydrogen gas. When thrown upon hot water, in contact with air, the sodium, and hydrogen inflame, producing a yellow flame, and a solution of hydrate of sodium ; cold water does not possess this property, the chemical action not being sufficiently energetic. The solution of hydrate of sodium is powerfully alkaline. When sodium is exposed to the air the metal immediately becomes coated with a crust of oxide. It unites with acids, forming a numerous class of salts.

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### OXIDE OF SODIUM.

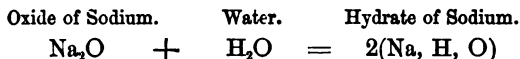
*Sodic Oxide.*

Symbol,  $\text{Na}_2\text{O}$  ; Equivalent, 62.

104. **PREPARATION.**—This compound is formed when sodium is burned in dry air.



**PROPERTIES.**—A white alkaline substance having a great affinity for water uniting with it, forming hydrate of sodium, thus :—



**TESTS.**—Neutral solutions of sodium salts give the following reactions with the reagents :—

1. A solution of tartaric acid does not produce a precipitate.
2. A solution of bichloride of platinum does not produce a precipitate.
3. Blowpipe flame—colour yellow.

### HYDRATE OF SODIUM.

#### *Sodic Hydrate.*

Symbol, Na, H, O ; Equivalent, 40.

105. This compound is also called Caustic Soda.

**PREPARATION.**—By boiling a dilute solution of carbonate of sodium, *sodic carbonate*, with hydrate of calcium, *calcic hydrate*, carbonate of calcium, *calcic carbonate*, and hydrate of sodium are formed. The subsequent operations are conducted in the manner described under the subject of hydrate of potassium, par. 70.

**PROPERTIES.**—A white solid, resembling hydrate of potassium in most of its properties, readily soluble in water, the solution is powerfully alkaline, with acids it forms a class of important salts. It is extensively employed in the manufacture of hard soap.

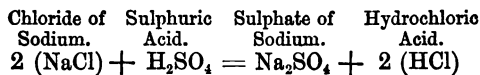
### MANUFACTURE OF CARBONATE OF SODIUM, WASHING SODA, AND SODA ASH.

106. The manufacture of carbonate of sodium is the most important of our British chemical manufactures. The oper-

ations may be divided into three : first, the production of "salt cake" (sulphate of sodium), second, its decomposition into carbonate of sodium or "black ash," third, its purification, crystallization, &c., into washing soda, or soda ash.

"Washing soda" is crystallized carbonate of sodium. "Soda ash" is anhydrous, impure carbonate of sodium.

1st PROCESS.—This consists in converting common salt (chloride of sodium) into sulphate of sodium, *sodic sulphate*, by the action of sulphuric acid, *hydric sulphate*, assisted by heat. Hydrochloric acid gas is evolved, and sulphate of sodium being formed, thus :—



Practically the whole of the chloride of sodium is not converted into pure sulphate of sodium. The author seldom found salt cake to contain more than 96 per cent. of sulphate of sodium. The following are the results of his analysis of a sample of salt cake :—

Sulphate of Sodium .....	96·200
„ Calcium .....	0·970
„ Magnesium .....	0·289
Chloride of Sodium .....	1·195
Peroxide of Iron.....	0·231
Silica... ..	0·314
Excess Acid ... ..	0·795
	<hr/>
	99·994
	<hr/>

2nd PROCESS.—The decomposition of the sulphate of sodium is effected by means of carbonate of calcium (limestones) and carbon (or small coal) ; the mixture being heated for some time in a reverberatory furnace ; the resulting mass which is called "black ash" has a highly complex composition. The following

are the results of the Author's analysis of a sample of black ash :—

Carbonate of sodium .....	36·640
Hydrated oxide of sodium .....	0·709
Sulphate of sodium .....	1·100
Sulphide of sodium .....	1·200
Chloride of sodium.....	1·713
Aluminate of sodium .....	2·250
Sulphide of calcium, and lime (3CaS +CaO) .....	29·070
Hydrated oxide of calcium.....	5·800
Silica .....	4·200
Sulphide of iron.....	4·717
Silicate of magnesium .....	3·044
Carbon .....	8·895
Ultramarine .....	0·275
	<hr/>
	99·613

3rd PROCESS.—The black ash usually contains about 36 per cent. of carbonate of sodium.

After lixiviation with water, the insoluble residue which is left in the vats is called "black ash waste."

The following analysis made by the Author of a sample of black ash waste will give the reader some idea of its composition :—

Carbonate of calcium .....	23·540
Sulphide of calcium, and [lime (3CaS +CaO) .....	21·060
Carbon .....	13·010
Silica .....	4·700
Silicate of magnesium .....	6·020
Peroxide of iron.....	5·025
Sulphate of calcium .....	4·200
Hydrated oxide of calcium .....	6·500
Sulphide of calcium .....	9·625
Sulphide of sodium .....	2·100
Water .....	3·950
	<hr/>
	99·730

The soluble portion of the black ash if crystallized yields "washing soda"  $\text{Na}_2\text{CO}_3 + 10(\text{H}_2\text{O})$ . If, however, the liquor is evaporated to dryness and heated almost red hot in a furnace, soda ash, or impure carbonate of sodium, is produced. A sample of "soda ash" which the Author submitted to chemical analysis, gave the following results:—

Carbonate of sodium .....	78.510
Hydrated oxide of sodium .....	10.681
Sulphate of sodium .....	8.400
Chloride of sodium .....	4.051
Sulphite of sodium.....	1.100
Aluminate of sodium .....	1.023
Silicate of sodium .....	0.942
Silica .....	0.810
Peroxide of iron .....	trace

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99.967

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#### ALKALIMETRY.

107. This process is exceedingly simple, and consists in adding a test acid liquor of known strength to a weighed portion of an alkaline salt, or substance (dissolved in water) until the solution is completely neutralized. This point is determined by means of tincture of litmus, and litmus paper, which are turned red by acids, and blue by alkalis. Neutral solutions have no effect upon the colour of litmus. The greater the number of measures of test acid used, the larger the per centage of alkali in the sample.

PREPARATION OF THE TEST ACID.—Sulphuric acid is diluted with water until it has a specific gravity of about 1.096 when cold. Weigh 53 grains of pure anhydrous carbonate of sodium, *sodic carbonate*, dissolve it in about three ounces of water, colour the solution blue with tincture of litmus, and apply a gentle heat, then fill an alkalimeter with the dilute acid, and add it drop by drop to the solution of carbonate of sodium, until it is perfectly converted into sulphate; the solution will then be neutral.

The number of measures of acid which have been required is equivalent to 81 grains of oxide of sodium, *sodic oxide*, that

being the amount contained in 58 grains of carbonate taken. If 81 measures of acid have been used, the strength of the test acid will be 100 measures = 100 of oxide of sodium.

In testing a sample of "soda ash" or soda salt, weigh 50 grains, dissolve in water, colour with litmus as above directed; then add your test acid from an alkalimeter until perfect neutralization is effected. Read off the scale of the alkalimeter, the number of measures used, and state by simple proportion, as the strength of the test acid ( $100 = 100$ ), so is the number of measures employed to  $x$  (the amount of oxide of sodium, *sodic oxide*, in the 50 grains of the compound taken). If this number be doubled, it will give the per centage of alkali in the sample.

The same test acid used for soda may be employed in testing the per centage of oxide of potassium, *potassic oxide*, in alkaline potash salts. A simple calculation, however, will be required to reduce the numbers for sodium salts to those of potassium salts, their respective equivalents being—oxide of sodium 62, and oxide of potassium 94.2.

EXAMPLE.—If 50 grains of a sample of potash required 24 measures of the above test acid, then :—

$$\text{As } 62 : 24 :: 94.2 : x = 36.4$$

$$\begin{array}{r} 3768 \\ 1884 \\ \hline 2260.8 \\ 186 \\ \hline 400 \\ 372 \\ \hline 288 \\ 248 \\ \hline 40 \end{array}$$

36.4 = the quantity of oxide of potassium contained in 50 grains.

From the above calculation, it will be seen that 50 grains contain 36.4 grains of oxide of potassium, *potassic oxide*, therefore 100 grains must necessarily contain 72.8 grains of oxide of potassium.

By changing the equivalent of oxide of potassium for that of ammonia, oxide of strontium, barium, calcium, or magnesium, the same test acid may be employed for estimating their respective per centages in many of their most important compounds. In testing solutions of ammonia, care must be taken not to apply heat, otherwise the ammonia gas will be dissipated and incorrect results be obtained.

### BICARBONATE OF SODIUM.

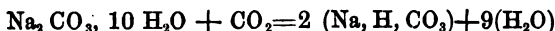
#### *Hydrosodic Carbonate.*

Symbol, Na, H, CO<sub>3</sub>; Equivalent, 84.

108. This salt is prepared by passing carbonic acid gas into chambers, containing crystallized carbonate of sodium.

One equivalent of carbonate of sodium uniting with one equivalent of carbonic acid gas, and two equivalents of bicarbonate of sodium are formed, thus :—

Crystallized Carbonate of Sodium.	Carbonic Acid.	Bicarbonate of Sodium.	Water.
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It is then dried at a steam heat to expel the nine equivalents of moisture.

### SULPHATE OF SODIUM.

#### *Sodic Sulphate.*

Symbol, Na<sub>2</sub>SO<sub>4</sub> + 10 (H<sub>2</sub>O); Equivalent, 322.

109. This compound is called Glauber's salt.

The commercial preparation of this salt has already been described under the subject of carbonate of sodium, par. 106. The pure salt is prepared by neutralizing a solution of carbonate

of sodium with dilute sulphuric acid, and leaving the solution to crystallize.

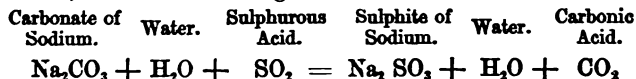
**PROPERTIES.**—A white crystalline neutral salt, readily soluble in water. Commercial "salt cake," (impure sulphate of sodium) is the source from which carbonate of sodium, *sodic carbonate*, is manufactured. The pure salt is extensively used in medicine.

### SULPHITE OF SODIUM.

#### *Sodic Sulphite.*

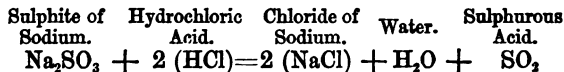
Symbol,  $\text{Na}_2\text{SO}_3$ ; Equivalent, 126.

**110. PREPARATION.**—Sulphurous acid gas is passed through a solution of carbonate of sodium, sulphite of sodium is formed, and carbonic acid gas is liberated, thus:—



The solution after evaporation, deposits crystals of the salt.

It is a white crystalline neutral salt, readily soluble in water. When a solution is treated with hydrochloric acid, it is decomposed, sulphurous acid gas being evolved, and chloride of sodium remaining in the solution, thus:



### HYPOSULPHITE OF SODIUM.

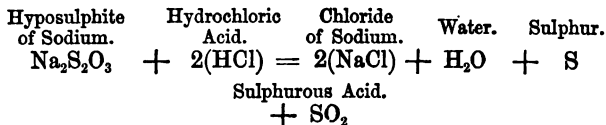
#### *Sodic Hyposulphite.*

Symbol,  $\text{Na}_2\text{S}_2\text{O}_3 + 5(\text{H}_2\text{O})$ ; Equivalent, 248.

**111.** The preparation of this salt, by boiling sulphite of sodium with sulphur, has been described under the subject of hyposulphurous acid.

**PROPERTIES.**—A white crystalline neutral salt, very soluble in water. When the solution is treated with hydrochloric acid, *hydric chloride*, it is decomposed, sulphurous acid gas

being evolved, sulphur deposited, and chloride of sodium remaining in solution, thus :—



Hyposulphite of sodium is extensively employed in photography, as a fixing agent.

### SULPHIDES OF SODIUM.

112. These compounds are prepared by the process described under the head of sulphides of potassium by simply substituting carbonate, or hydrate of sodium, for carbonate, or hydrate of potassium. Their physical, and chemical properties are almost identical with those of potassium sulphides.

### CHLORIDE OF SODIUM.

*Sodic Chloride.*

Symbol,  $\text{NaCl}$ ; Equivalent, 58.46.

113. This compound is generally known by the name of "common salt." It exists native in immense quantities in Cheshire, &c.

PREPARATION.—It may be prepared by neutralizing carbonate of sodium, *sodic chloride*, with hydrochloric acid. Upon evaporation the salt is deposited in minute crystals.

PROPERTIES.—A white crystalline neutral salt. It is the source of chlorine, hydrochloric acid, and washing soda, &c., and is largely employed in preparing food, and preserving meat.

### NITRATE OF SODIUM.

*Sodic Nitrate.*

Symbol,  $\text{NaNO}_3$ ; Equivalent, 85.

114. This salt occurs native in immense quantities in Chili.

PREPARATION.—It can be prepared pure by neutralizing a solution of carbonate of sodium, with dilute nitric acid, *hydric nitrate*. Upon evaporation the salt is obtained in crystals.



**PROPERTIES.**—A white crystalline salt, deliquescent, and very soluble in water. It is largely used in the manufacture of nitric acid, and in the manufacture of saltpetre.

### BIBORATE OF SODIUM.

*Sodic Diborate.*

Symbol,  $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10 (\text{H}_2\text{O})$ ; Equivalent, 382.16.

115. This salt is commonly called "borax." It exists native in a crude state in Persia, &c., and can be purified by solution and crystallization. It may be prepared from native boracic acid by treatment with carbonate of sodium, filtration, and subsequent crystallization.

**PROPERTIES.**—A white crystalline efflorescent salt, soluble in water; the solution has an alkaline reaction to test paper. It is employed in porcelain, and glass staining, and painting; also as a blowpipe reagent for the discrimination of metals, with some of which it forms characteristic coloured compounds.

### ACETATE OF SODIUM.

*Sodic Acetate.*

Symbol,  $\text{NaC}_2\text{H}_3\text{O}_2 + 3(\text{H}_2\text{O})$ ; Equivalent 136.

116. **PREPARATION.**—When a solution of carbonate of sodium, *sodium carbonate*, is neutralized by acetic acid, acetate of sodium is formed, and carbonic gas is given off.

**PROPERTIES.**—A white crystalline neutral salt, soluble in water, blackens when heated being decomposed into carbonate of sodium, and formation of free carbon, &c. A solution of the salt is employed as a reagent in the laboratory.

### PHOSPHATES OF SODIUM.

Monobasic phosphate of sodium,  $\text{Na}_3\text{P}_3\text{O}_9$ , *trisodic triphosphate*.

Dibasic phosphate of sodium,  $\text{Na}_2\text{P}_2\text{O}_6 + 5(\text{H}_2\text{O})$ , *disodic diphosphate*.

Tribasic phosphate of sodium,  $\text{Na}_2\text{H}_2\text{P}_2\text{O}_7 + 12(\text{H}_2\text{O})$ , *hydro disodic phosphate*.

## MONOBASIC PHOSPHATE OF SODIUM.

117. This salt is also called metaphosphate of soda.

PREPARATION.—When tribasic phosphate of hydrogen, sodium, and ammonium, is heated red hot, ammonia gas, and water vapour are expelled, and this salt remains in the crucible.

PROPERTIES.—A white deliquescent solid, very soluble in water; the solution produces a white precipitate with a solution of nitrate of silver, *argentic nitrate*. By fusion with carbonate of sodium, monobasic phosphate of sodium is converted into the tribasic phosphate of sodium.

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## BIBASIC PHOSPHATE OF SODIUM.

118. This salt is also called pyrophosphate of soda.

PREPARATION.—If common tribasic phosphate of sodium be heated it loses water, and becomes changed into this salt. By solution in water, and evaporation; the salt is obtained in crystals.

PROPERTIES.—A white crystalline salt, soluble in water; the solution has an alkaline reaction to test paper, and produces a white precipitate with a solution of nitrate of silver, *argentic nitrate*. When fused with carbonate of sodium, *sodic carbonate*, it is converted into the tribasic condition.

---

## TRIBASIC PHOSPHATE OF SODIUM.

119. This salt is prepared by decomposing a solution of acid phosphate of calcium (obtained by acting upon ground bone ash with sulphuric acid) with carbonate of sodium; carbonate of calcium, *calcic carbonate*, is precipitated, and tribasic phosphate of sodium remains in solution. Upon decanting the clear liquor, and concentrating the solution by evaporation, the salt crystallizes.

PROPERTIES.—A white crystalline salt, soluble in water, having an alkaline reaction to test paper. With a solution of nitrate of silver it produces a yellow precipitate.

## SILICATE OF SODIUM.

*Sodic Silicate.*Symbol,  $\text{NaSiO}_3$ .

120. PREPARATION.—This salt is commercially prepared by fusing for some hours a mixture of sand (silica), and soda ash (impure carbonate of sodium), in a furnace.

PROPERTIES.—The compound prepared by the above process resembles glass in most of its physical properties; it is soluble, however, in water, and is therefore, called “water glass.” The solution has an alkaline reaction to test paper. By exposure to the air, it is decomposed by the carbonic acid, hydrated silicic acid, gelatinizes, and carbonate of sodium, *sodic carbonate*, is formed. It is largely used by soap manufacturers, and calico printers.

## AMMONIUM.

Symbol,  $\text{NH}_4$ ; Equivalent, 18.

121. This compound metallic radical has not been isolated. It unites with acids, producing ammonium salts. Oxide of ammonium  $(\text{NH}_4)_2\text{O}$  may theoretically be considered as liquid ammonia. By some authorities ammonium is considered to be the hydride of ammonia gas  $\text{NH}_3$ , H; and liquid ammonia is therefore an hydrate of ammonia gas  $(\text{NH}_3)_2 \text{H}_2\text{O}$ ,  $(\text{NH}_3, \text{HO})$ .

The preparation of ammonia gas has been fully described under the subject of nitrogen and its compounds, par. 19.

TESTS.—Neutral solutions of ammonium salts give the following reactions:—

1. Upon adding a solution of hydrate of potassium, *potassic hydrate*, and applying a gentle heat ammonia gas is evolved, and may be recognised by its characteristic odour. If a stirring rod, moistened with hydrochloric or acetic acids, be held over the mouth of the test tube, white fumes are produced, and if a red litmus paper be exposed to the action of the gas it will be turned blue.

2. A solution of bichloride of platinum gives a yellow crystalline precipitate of chloride of platinum, and ammonium.
  3. Upon evaporating the solution to dryness, and heating the residue upon platinum foil, the compound completely volatilizes.
- 

### SESQUICARBONATE OF AMMONIUM.

122. This compound is prepared by subliming a mixture of chloride of ammonium, *ammonic chloride*, and carbonate of calcium (chalk), *calcic carbonate*.

PROPERTIES.—A white, semi-transparent solid, having a pungent odour of ammonia. When exposed to the air it becomes converted into a white powder (bicarbonate of ammonium  $(\text{NH}_4, \text{H}, \text{CO}_3)$  with the disengagement of neutral carbonate of ammonium, *ammonic carbonate*. It is soluble in water, and the solution is powerfully alkaline.

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### BICARBONATE OF AMMONIUM.

Symbol,  $\text{NH}_4, \text{H}, \text{CO}_3$ ; Equivalent, 79.

123. This salt is formed when commercial sesquicarbonate of ammonium is exposed to the air. By solution in water, and concentration, the salt is deposited in crystals.

PROPERTIES.—A white inodorous salt, soluble in water; the solution possesses an alkaline reaction.

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### CHLORIDE OF AMMONIUM.

*Ammonic Chloride.*

Symbol,  $\text{HN}_3\text{Cl}$ ; Equivalent, 53.46.

124. This salt is commonly called "sal-ammoniac."

PREPARATION.—The salt is largely prepared from the ammoniacal liquor or gas water of our gas works. The liquor

is first neutralized with hydrochloric acid, *hydric chloride*, and then evaporated to dryness. The application of heat is continued until most of the tarry matters are expelled; it is then sublimed in iron vessels. By solution in water, and crystallization, it can be obtained in a moderate state of purity.

PROPERTIES.—A white neutral compound, soluble in water. A solution of this compound is employed as a reagent, and the salt is largely used for the preparation of ammonia gas in the laboratory.

### SULPHATE OF AMMONIUM.

#### *Ammonic Sulphate.*

Symbol,  $(\text{NH}_4)_2 \text{SO}_4$ ; Equivalent, 132.

125. PREPARATION.—This salt is commercially prepared by adding sulphuric acid, *hydric sulphate*, in slight excess to gas water. Upon evaporating the solution, impure crystals are formed. By repeated solution, and crystallization, the salt may be obtained tolerably pure. Pure sulphate of ammonium is prepared by neutralizing hydrate or carbonate of ammonium with sulphuric acid, and allowing the solution to crystallize.

PROPERTIES.—A white crystalline neutral salt, soluble in water. The impure salt is extensively employed by the agriculturalists, and artificial manure manufacturers as a fertilizer.

### NITRATE OF AMMONIUM.

#### *Ammonic Nitrate.*

Symbol,  $\text{NH}_4 \text{NO}_3$ ; Equivalent, 80.

126. PREPARATION.—It is usually prepared from carbonate of ammonium, and nitric acid, *hydric nitrate*. The diluted acid is added until neutralization is effected. Upon evaporation, and subsequent crystallization the salt is obtained.

PROPERTIES.—A white, crystalline neutral salt, and dissolves readily in water. It is employed for the preparation of nitrous oxide gas.

### SULPHIDES OF AMMONIUM.

#### SULPHIDE OF AMMONIUM AND HYDROGEN.

#### *HydroAmmonic Sulphide.*

Symbol,  $\text{NH}_4, \text{H}, \text{S}$ .

127. It is commonly called hydrosulphate of ammonia.

PREPARATION.—Liquid ammonia is diluted with ten times its volume of water, and a stream of sulphide of hydrogen gas passed through the solution, as long as absorption of the gas takes place.

PROPERTIES.—A colourless alkaline liquid, having a fetid odour, and is a most valuable re-agent to the analyst.

---

### YELLOW SULPHIDE OF AMMONIUM.

#### *Ammonic Sulphide.*

Symbol,  $(\text{NH}_4)_2\text{S}$ ; Equivalent, 68.

128. PREPARATION.—By warming a solution of sulphide of ammonium, and hydrogen with excess of sulphur, a yellow solution of sulphide of ammonium is obtained upon filtration. It is a yellow, alkaline liquid resembling the last-mentioned compound, and is employed as a re-agent.

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### OXALATE OF AMMONIUM.

#### *Ammonic Oxalate.*

Symbol,  $(\text{NH}_4)_2\text{C}_2\text{O}_4$ ; Equivalent, 124.

129. PREPARATION.—By dissolving carbonate of ammonium in water, and neutralizing the solution with oxalic acid, oxalate of ammonium is formed, and may be obtained in crystals by allowing the solution to evaporate slowly.

PROPERTIES.—A neutral crystalline salt, soluble in water, and is employed as a reagent for the detection of calcium.

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### LITHIUM.

Symbol, Li: Equivalent, 6.95.

130. This element exists in small proportions in petallite, lepidollite, and other minerals.

PREPARATION.—By passing a strong current of electricity through the fused chloride.

**PROPERTIES.**—A white metal, resembling potassium, and sodium in its leading physical, and chemical properties. It is remarkably light, having a specific gravity of only 0.58. When exposed to the air it changes into oxide. With acids it enters into combination, forming salts.

---

### OXIDE OF LITHIUM.

#### *Lithic Oxide.*

Symbol,  $\text{Li}_2\text{O}$  ; Equivalent, 29.90.

131. When lithium is heated in contact with air, it ignites, burning with a crimson flame, and is converted into oxide.

**PROPERTIES.**—A white alkaline compound, possessing a great affinity for water, with which it unites, forming hydrate of lithium.

**TESTS.**—Strong solutions of neutral lithium salts, give the following reactions :—

1. With a solution of carbonate of sodium, a white precipitate of carbonate of lithium.
2. With a solution of common phosphate of sodium, a white precipitate of phosphate of lithium.
3. Blowpipe flame—colour crimson.

132. The compounds of lithium with acids have a remarkable resemblance to the corresponding salts of sodium, and potassium, and they may be prepared by the same processes already described, simply substituting lithium for potassium or sodium. They have not been applied to any very useful purpose. The phosphate, hydrate, and carbonate are only slightly soluble in water as compared with the phosphate, hydrate, and carbonate of potassium or sodium.

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### CÆSIUM.

Symbol, Cs ; Equivalent, 133.

133. This element exists in small proportions in several minerals, such as lepidollite, petallite, &c. It resembles potassium in its principal properties, forming a double salt with bichloride of platinum. When exposed to the air the

metal speedily becomes oxidized. The oxide is powerfully alkaline, and unites with acids forming salts. The carbonate of cæsium, *cæsic carbonate*, is soluble in alcohol.

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### RUBIDIUM.

Symbol, Rb; Equivalent, 85.40.

134. This element exists in small quantities in lepidollite, petallite, &c., and other minerals. It resembles cæsium in almost all its properties, forming a double salt with bichloride of platinum, *platinic chloride*. Upon exposure to air the metal becomes converted into alkaline oxide of rubidium. With acids it forms crystallizable salts. The carbonate of rubidium, *rubidic carbonate*, is only slightly soluble in alcohol; by means of this solvent the carbonates of rubidium, and cæsium are separated when existing in combination.

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## CHAPTER III.

## THE ALKALINE EARTHS.

## BARIUM.

Symbol, Pa ; Equivalent, 137.18.

135. This element occurs in nature in combination with carbonic, and sulphuric acids, as carbonate (witherite) and sulphate (heavy spar).

PREPARATION.--By passing potassium vapour through a red hot gun barrel containing oxide of barium, *baric oxide*; upon cooling it is treated with mercury, which enters into combination with the barium, forming a fluid amalgam. Upon subjecting the mercurial compound to distillation, metallic barium remains in the retort, and mercury distils over into the receiver.

PROPERTIES.—A silvery white metal, oxidizes when exposed to the air; decomposes water, forming hydrate of barium, *baric hydrate*, accompanied with the liberation of hydrogen gas.

## OXIDE OF BARIUM.

*Baric Oxide.*

Symbol, BaO ; Equivalent, 153.18.

136. PREPARATION.—Nitrate of barium, *baric nitrate*, is heated red hot for some time in a crucible; decomposition of the salt takes place, nitrous acid, and oxygen gases being liberated, and oxide of barium remaining in the crucible, thus:—

Nitrate of Barium. Oxide of Barium. Nitrous Acid. Oxygen.



PROPERTIES.—An alkaline solid, soluble in water with which it enters into combination, forming hydrate of barium ; with acids it forms salts.

TESTS.—Neutral solutions of barium salts, give the following reactions :—

1. Dilute sulphuric acid, produces an immediate white precipitate of sulphate of barium, *baric sulphate*.
2. A solution of carbonate of sodium, *sodic carbonate*, gives a white precipitate of carbonate of barium, *baric carbonate*.
3. A solution of hydrofluosilicic acid, produces a white precipitate of hydrofluosilicate of barium, *baric hydrofluosilicate*.
4. Blowpipe flame—colour pale green.

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### BINOXIDE OF BARIUM.

#### *Baric Peroxide.*

Symbol,  $\text{BaO}_2$  ; Equivalent, 169.18.

137. PREPARATION.—This is prepared by passing oxygen gas, through red hot oxide of barium.

PROPERTIES.—A grey coloured compound, soluble in water, with which it unites, forming hydrate. The compound is used for the preparation of binoxide of hydrogen, par. 10.

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### HYDRATE OF BARIUM.

#### *Baric Hydrate.*

Symbol,  $\text{BaO}, \text{H}_2\text{O}$  ; Equivalent, 171.18.

138. PREPARATION.—To a concentrated solution of chloride of barium, *baric chloride*, a solution of hydrate of sodium, *sodic hydrate*, is added ; the whole is boiled for a few minutes to effect the decomposition of the chloride, and then allowed to crystallize. The crystals of hydrate of barium obtained may be purified by recrystallization.

**PROPERTIES.**—A white solid, soluble in water, the solution is strongly alkaline, and is a valuable reagent for the detection of carbonic acid.

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### CHLORIDE OF BARIUM.

#### *Baric Chloride.*

Symbol,  $\text{BaCl}_2 + 2(\text{H}_2\text{O})$ ; Equivalent, 244.10.

**139. PREPARATION.**—If carbonate of barium, *baric carbonate*, be dissolved in dilute hydrochloric acid, *hydric chloride*, and the solution after filtration be concentrated by evaporation, crystals of this salt will be deposited upon cooling.

**PROPERTIES.**—A crystalline neutral salt, soluble in water, a most valuable reagent for the detection, and quantitative determination of sulphuric acid.

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### NITRATE OF BARIUM.

#### *Baric Nitrate.*

Symbol,  $\text{Ba}(\text{NO}_3)_2$ ; Equivalent, 261.18.

**140. PREPARATION.**—When carbonate of barium is dissolved in dilute nitric acid, *hydric nitrate*, this salt is formed, and can be obtained in the solid form by submitting the solution to the operation of crystallization.

**PROPERTIES.**—A crystalline neutral salt, soluble in water. The solution is employed as a reagent for similar purposes as that of the chloride. It is also employed by the pyrotechnist for the preparation of "green fire."

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### SULPHATE OF BARIUM.

#### *Baric Sulphate.*

Symbol,  $\text{BaSO}_4$ ; Equivalent, 233.18.

**141.** This compound exists native in Derbyshire, &c.

**PREPARATION.**—Upon adding dilute sulphuric acid to a solution of barium, a white precipitate of sulphate of barium

is formed. The precipitate is collected on a filter, washed with water, and dried.

PROPERTIES.—A heavy white neutral salt, insoluble in water, and dilute acids. It is employed for adulterating white lead, and for giving weight to paper, and calico, &c.

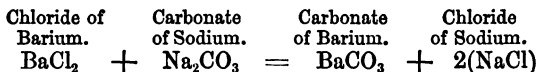
### CARBONATE OF BARIUM.

#### *Baric Carbonate.*

Symbol,  $\text{BaCO}_3$ ; Equivalent, 197.18.

142. This compound exists native in Derbyshire, &c.

PREPARATION.—It may be prepared from a solution of nitrate, or chloride of barium by precipitation with carbonate of sodium, thus :—



The precipitate is collected on a filter, washed with water, and dried.

PROPERTIES.—A heavy white solid, slightly soluble in water, readily soluble with effervescence in dilute nitric, or hydrochloric acids.

### SULPHIDE OF BARIUM.

#### *Baric Sulphide.*

Symbol,  $\text{BaS}$ ; Equivalent, 169.34.

143. PREPARATION.—Powdered sulphate of barium, *baric sulphate*, is mixed with ground coal, introduced into a furnace, and exposed to a strong heat; the sulphate is reduced to the state of sulphide. The mass upon cooling is treated with water which dissolves the sulphide; after filtration the solution is concentrated by evaporation; upon cooling crystals of sulphide of barium are deposited.

PROPERTIES.—A crystalline salt, soluble in water.

### STRONTIUM.

Symbol,  $\text{Sr}$ ; Equivalent, 87.34.

144. This element exists in nature in combination with carbonic, and sulphuric acids, as carbonate, and sulphate of strontium.

**PREPARATION.**—Metallic strontium is obtained from the oxide by the action of potassium vapour, by the same process as that described for the preparation of barium.

**PROPERTIES.**—A heavy metal, oxidizes when exposed to the air, decomposes water with the formation of an alkaline hydrate, and evolution of hydrogen gas. It unites with acids, forming salts.

## OXIDE OF STRONTIUM.

### *Strontic Oxide.*

Symbol,  $\text{SrO}$  ; Equivalent, 108·84.

**145. PREPARATION.**—This compound is formed when nitrate of strontium, *strontic nitrate*, is heated red hot in a crucible for some hours. The nitrate is decomposed in the same manner as nitrate of barium, *baric nitrate*, viz., oxide of strontium remains in the crucible, and nitrous acid, and oxygen are liberated.

**PROPERTIES.**—An alkaline compound resembling oxide of barium, *baric oxide*, soluble in water uniting with it, forming hydrate of strontium, *strontic hydrate*, and unites with acids, forming salts.

**TESTS.**—Neutral solutions containing strontium salts produce the following reactions with the reagents :—

1. Dilute sulphuric acid, *hydric sulphate*, produces a white precipitate of sulphate of strontium, *strontic sulphate*.
2. A solution of carbonate of sodium, *sodic carbonate*, produces a white precipitate of carbonate of strontium, *strontic carbonate*.
3. Hydrofluosilicic acid produces no precipitate.
4. Blowpipe flame—colour scarlet.

## NITRATE OF STRONTIUM.

### *Strontic Nitrate.*

Symbol,  $\text{Sr}(\text{NO}_3)_2 + 5(\text{H}_2\text{O})$  ; Equivalent, 301·84.

**146. PREPARATION.**—Powdered carbonate of strontium, *strontic carbonate*, is dissolved in dilute nitric acid, *hydric*

*nitrate*, aided by heat; the solution after filtration is allowed to crystallize.

PROPERTIES.—A neutral crystalline salt, soluble in water. It is the most important of the strontium compounds, being largely employed by the pyrotechnist for the preparation of “red fire.”

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### CHLORIDE OF STRONTIUM.

#### *Strontic Chloride.*

Symbol,  $\text{SrCl}_2 + 6(\text{H}_2\text{O})$ ; Equivalent, 266.26.

147. PREPARATION.—By the action of dilute hydrochloric acid, *hydric chloride*, upon carbonate of strontium, *strontic carbonate*, assisted by heat; the solution is filtered, and the salt crystallizes upon cooling.

PROPERTIES.—A crystalline neutral salt, slightly deliquescent.

---

### CARBONATE OF STRONTIUM.

#### *Strontic Carbonate.*

Symbol,  $\text{SrCO}_3$ ; Equivalent, 147.84.

148. This compound exists native.

PREPARATION.—It may be prepared from nitrate of strontium, *strontic nitrate*, by solution in water and addition of carbonate of sodium, *sodic carbonate*; carbonate of strontium is precipitated, and may be collected on a filter, nitrate of sodium, *sodic nitrate*, remaining in solution.

PROPERTIES.—A white neutral compound, insoluble in water, soluble in dilute hydrochloric, or nitric acids, &c.

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### SULPHATE OF STRONTIUM.

#### *Strontic Sulphate.*

Symbol,  $\text{SrSO}_4$ ; Equivalent, 189.84.

149. This compound exists native.

**PREPARATION.**—Upon the addition of dilute sulphuric acid to a solution of any strontium salt, this compound is precipitated, and may be collected on a filter, washed, and dried.

**PROPERTIES.**—A white neutral compound, insoluble in water, and dilute acids.

### CALCIUM.

Symbol, Ca ; Equivalent, 40.

150. The element exists in immense quantities in combination with carbonic, sulphuric, and phosphoric acids, &c.

**PREPARATION.**—The metal is obtained by means similar to those already described under the preparation of barium, and strontium.

**PROPERTIES.**—A white malleable ductile metal, oxidizes slowly when exposed to the air.

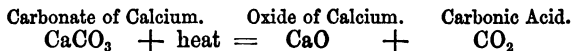
### OXIDE OF CALCIUM.

*Calcic Oxide.*

Symbol, CaO ; Equivalent, 56.

151. This compound is commonly called “lime” or “quick lime.”

**PREPARATION.**—Impure lime is prepared from the native carbonate of calcium (limestones) by the action of heat. The limestones are mixed with coal and introduced into lime kilns, where they are calcined at a red heat for some hours ; carbonic acid gas is disengaged and oxide of calcium is formed thus :—



Pure oxide of calcium is prepared, by first precipitating as carbonate a solution of chloride of calcium, with a solution of carbonate of sodium, *sodic carbonate* ; chloride of sodium, *sodic chloride*, remains in solution. The carbonate is collected upon a filter, well washed, dried, and burned, when carbonic acid gas is given off, and oxide of calcium remains.

**PROPERTIES.**—A white alkaline compound, slightly soluble in water, with which it combines with the production of great heat forming hydrate of calcium (slacked lime). It unites with acids forming salts.

**TESTS.**—Neutral solutions of calcium salts produce the following reactions with the reagents:—

1. Dilute sulphuric acid produces no precipitate.
2. A solution of oxalate of ammonium produces a white precipitate of oxalate of calcium, *calcic oxalate*.
3. A solution of carbonate of sodium, *sodic carbonate*, produces a white precipitate of carbonate of calcium, *calcic carbonate*.
4. Blowpipe flame—colour orange red.

---

### HYDRATE OF CALCIUM.

#### *Calcic Hydrate.*

Symbol,  $\text{CaO}$ ,  $\text{H}_2\text{O}$ ; Equivalent, 74.

**152. PREPARATION.**—By the addition of water to “quick lime” (oxide of calcium); the lime “slacks” becoming converted into hydrate.

**PROPERTIES.**—A white alkaline powder, slightly soluble in cold water, and less soluble in hot water. The solution has an alkaline reaction, and is employed as a reagent for the detection of carbonic acid, with which it immediately produces a white precipitate.

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### CHLORIDE OF CALCIUM.

#### *Calcic Chloride.*

Symbol,  $\text{CaCl}_2$ ; Equivalent, 110.92.

**153.**—This salt is a waste product in the manufacture of carbonic acid, from limestones, (carbonate of calcium); by the action of hydrochloric acid, *hydric chloride*.

**PROPERTIES.**—A neutral salt, extremely soluble in water and alcohol, and is deliquescent. The power which the fused



salt possesses of absorbing moisture, renders it a valuable agent for drying gases, and for the quantitative estimation of water, vapour, &c.

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### SULPHIDE OF CALCIUM.

#### *Calcic Sulphide.*

Symbol,  $\text{CaS}$ ; Equivalent, 72.

154. PREPARATION.—A mixture of powdered sulphate of calcium, *calcic sulphate*, and charcoal are heated for some hours in a crucible. The mass is allowed to cool, and is then treated with water; a solution of protosulphide of calcium is obtained, which upon evaporation yields this compound in a solid form.

PROPERTIES.—An alkaline solid, slightly soluble in water.

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### PHOSPHIDE OF CALCIUM.

#### *Calcic Phosphide.*

Symbol,  $\text{CaP}_2$ , Equivalent, 102.

155. PREPARATION.—Phosphorus vapour is passed through a red hot tube containing pieces of oxide of calcium, *calcic oxide*, when phosphide of calcium is formed.

PROPERTIES.—A brown compound; when thrown into water it is decomposed, phosphide of hydrogen gas is liberated.

---

### SULPHATE OF CALCIUM.

#### *Calcic Sulphate.*

Symbol,  $\text{CaSO}_4$ ; Equivalent, 136.

156. This compound exists native as gypsum, selenite, &c.

PREPARATION.—It may be prepared by precipitation as hydrated sulphate, by adding dilute sulphuric acid, *hydric sulphate*, to a concentrated solution of chloride of calcium, *calcic chloride*. If the hydrate be strongly heated, it becomes anhydrous.

PROPERTIES.—A white compound, insoluble in water, and dilute acids. The anhydrous sulphate (plaster of paris) unites with water forming a solid hydrated sulphate of calcium. The

permanent hardness of water is generally caused by the presence of this salt (see hardness of water, par 9).

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## CARBONATE OF CALCIUM.

### *Calcic Carbonate.*

Symbol,  $\text{CaCO}_3$ ; Equivalent, 100.

157. This compound exists in nature as limestone, chalk, marble, &c.

PREPARATION.—When a solution of carbonate of sodium, *sodic carbonate*, is added to a solution of chloride of calcium, *calcic chloride*, carbonate of calcium, *calcic carbonate*, is precipitated, and chloride of sodium, *sodic chloride*, remains in solution. The precipitate is collected upon a filter, washed, and dried.

PROPERTIES.—A white solid, insoluble in water, readily soluble in acids. The permanent hardness of water is due to the presence of this salt in combination with carbonic acid in solution as bicarbonate ( $\text{CaCO}_3, \text{H}_2\text{CO}_3$ ), see hardness of water, par 9.

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## PHOSPHATES OF CALCIUM.

158. Bones, and a mineral named apatite, are principally phosphate of calcium.

Tribasic phosphate of calcium	}	$\text{Ca}_3(\text{PO}_4)_2$
	}	<i>Tricalcic phosphate.</i>
Tribasic acid phosphate of calcium	}	$\text{H, Ca, PO}_4$
	}	<i>Hydrocalcic phosphate.</i>
Tribasic acid phosphate of calcium	}	$\text{H}_4, \text{Ca, (PO}_4)_2$
	}	<i>Tetrahydro calcic phosphate.</i>
Bibasic phosphate of calcium	}	$\text{CaP}_2\text{O}_6$
	}	<i>Calcic diphosphate.</i>
Monobasic phosphate of calcium	}	$\text{Ca}_3(\text{P}_3\text{O}_9)_2$
	}	<i>Tricalcic triphosphate</i>

## TRIBASIC NEUTRAL PHOSPHATE OF CALCIUM.

*Tricalcic Phosphate.*

159. PREPARATION.—A solution of chloride of calcium, *calcic chloride*, is added to a solution of neutral tribasic phosphate of sodium, *trisodic phosphate*; this salt is precipitated, and chloride of sodium remains in solution.

PROPERTIES.—A white neutral substance, insoluble in water, soluble in acids.

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## TRIBASIC ACID PHOSPHATE OF CALCIUM.

*Hydrocalcic Phosphate.*

160. PREPARATION.—A solution of chloride of calcium, *calcic chloride*, is added to a solution of common phosphate of sodium, *hydro disodic phosphate*; a precipitate of this salt is obtained, and chloride of sodium remains in solution.

PROPERTIES.—A white crystalline solid, insoluble in water, soluble in acids.

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## TRIBASIC ACID PHOSPHATE OF CALCIUM.

*Tetrahydro Calcic Phosphate.*

161. PREPARATION.—If the preceding salt be dissolved in dilute phosphoric acid, the solution deposits crystals of this salt after evaporation.

PROPERTIES.—A white crystalline acid salt, soluble in water.

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## BIBASIC PHOSPHATE OF CALCIUM.

*Calcic Diphosphate.*

162. PREPARATION.—To a solution of chloride of calcium, *calcic chloride*, a solution of bibasic phosphate of sodium is added, the precipitate consists of bibasic phosphate of calcium, and chloride of sodium is held in solution.

PROPERTIES.—A white solid substance, insoluble in water, soluble in dilute acids.

## MONOBASIC PHOSPHATE OF CALCIUM.

*Tricalcic Triphosphate.*

163. PREPARATION.—This compound is prepared by adding a solution of monobasic phosphate of sodium to a solution of chloride of calcium; the precipitate may be collected on a filter, washed, and dried.

PROPERTIES.—A white solid substance, insoluble in water, soluble in dilute acids.

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## FLUORIDE OF CALCIUM.

*Calcic Fluoride.*

Symbol,  $\text{CaF}_2$ ; Equivalent, 78.

164. This compound exists native as fluor-spar in large quantities in Derbyshire, &c.

PROPERTIES.—A white crystalline solid, insoluble in water, and dilute acids. It is decomposed when heated with concentrated sulphuric acid, *hydric sulphate*, being converted into sulphate of calcium, *calcic sulphate*, with the evolution of hydrofluoric acid gas.

---

## NITRATE OF CALCIUM.

*Calcic Nitrate.*

Symbol,  $\text{Ca}(\text{NO}_3)_2$ ; Equivalent, 164.

165. PREPARATION.—By dissolving chalk (carbonate of calcium) in dilute nitric acid, *hydric nitrate*. The solution upon evaporation yields the salt.

PROPERTIES.—A white neutral salt, readily soluble in water.

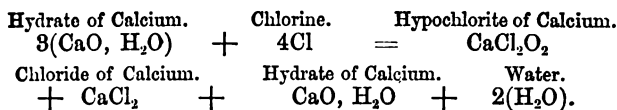
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## HYPOCHLORITE OF CALCIUM. (Bleaching Powder.)

*Calcic Hypochlorite.*

166. PREPARATION.—This important bleaching agent is commercially prepared from hydrate of calcium, *calcic hydrate* (slacked lime), by the action of chlorine gas. Slacked lime

is spread upon the brick floor of chambers, into which a stream of chlorine gas is passed for some days; a mixture of hypochlorite of calcium with chloride of calcium, and unchanged hydrate of calcium is obtained, which is called bleaching powder or chloride of lime. The reaction which takes place between the hydrate of calcium and chlorine may be expressed thus:—



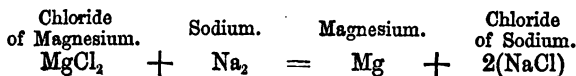
PROPERTIES.—A white compound, possessing an odour of chlorine, partially soluble in water. The hypochlorite and chloride of calcium are readily soluble in water, the hydrate of calcium, however, with which it is associated, is only slightly soluble. When exposed to air it is decomposed by the carbonic acid, chlorine being liberated. It is a valuable bleaching and disinfecting agent. For the process of determination of the commercial value of samples of bleaching powder, see Chlorimetry, par. 46.

### MAGNESIUM.

Symbol, Mg; Equivalent, 24.

167. This element exists in combination with carbonic acid as dolomite, and as sulphate, &c.

PREPARATION.—This metal has, within the last two years, been extensively manufactured by the action of sodium upon chloride of magnesium. The fused chloride of magnesium is mixed with sodium, introduced into a crucible, the lid luted down, and heat applied for some hours. After cooling the mass is treated with water, which dissolves the chloride of sodium, *sodic chloride*, formed, leaving impure magnesium. Upon distilling the crude metal, pure magnesium is obtained. The decomposition which takes place when sodium and chloride of magnesium are heated together, may be expressed thus:—



PROPERTIES.—A silvery white ductile metal, having a remarkably low specific gravity (1.7). When exposed to dry air it does not suffer oxidation; it is slowly acted upon by water being converted into oxide. It dissolves readily in acids; when strongly heated in contact with air, it inflames, burning with a dazzling white light forming oxide. It may be distilled at a red heat.

---

### OXIDE OF MAGNESIUM.

*Magnesium Oxide.*

Symbol,  $MgO$ ; Equivalent, 40.

168. PREPARATION.—This compound is formed when magnesium is burned in air or oxygen, or when carbonate of magnesium, *magnesium carbonate*, is strongly heated.

PROPERTIES.—A white solid, and unites with water forming hydrate, which is very slightly soluble in water; the solution has an alkaline reaction. It unites with acids forming salts.

TESTS.—Solutions of magnesium give the following reactions:—

1. With a solution of carbonate of sodium, *sodic carbonate*, a white precipitate of carbonate of magnesium, *magnesium carbonate*.
  2. With dilute sulphuric acid, *hydric sulphate*, no precipitate.
  3. With a solution of phosphate of sodium, and the addition of a few drops of ammonia, a white precipitate of phosphate of magnesium and ammonium.
  4. Blowpipe flame—colourless.
- 

### SULPHATE OF MAGNESIUM.

*Magnesium Sulphate.*

Symbol,  $MgSO_4 + 7(H_2O)$ ; Equivalent, 246.

169.—This salt is commonly called “Epsom salt.”

PREPARATION.—When powdered dolomite or magnesium limestones are treated with dilute sulphuric acid, *hydric sul-*

*phate*, sulphates of magnesium and calcium are formed, and carbonic acid gas is evolved. The sulphate of calcium, *calcic sulphate*, is only slightly soluble in water, whilst the sulphate of magnesium is readily so. The calcium salt precipitates to the bottom of the vats, leaving the magnesium salt in solution. The liquor is decanted, evaporated, and allowed to cool; crystals of sulphate of magnesium are deposited and may be purified by recrystallization.

PROPERTIES.—A white crystalline neutral salt, soluble in water. It is principally employed in medicine. A solution of the salt is employed as a reagent in the laboratory.

---

### CHLORIDE OF MAGNESIUM.

#### *Magnesium Chloride.*

Symbol,  $\text{MgCl}_2$ ; Equivalent, 94.92.

170. PREPARATION.—This salt is prepared by dissolving the carbonate of magnesium, *magnesium carbonate*, in dilute hydrochloric acid, *hydric chloride*, and adding chloride of ammonium, *ammonium chloride*. After evaporating the solution to dryness, the mass is cautiously heated until the chloride of ammonium is volatilized, leaving chloride of magnesium. The addition of the chloride of ammonium is to prevent the spontaneous decomposition of a portion of the chloride of magnesium, which would occur when the solution is evaporated, unless this salt be previously added.

PROPERTIES.—A white neutral deliquescent solid, very soluble in water and alcohol.

---

### CARBONATE OF MAGNESIUM.

#### *Magnesium Carbonate.*

Symbol,  $\text{MgCO}_3$ ; Equivalent, 84.

171. This compound exists native in combination with carbonate of calcium, *calcic carbonate*, as dolomite, &c.

PREPARATION.—A hot solution of carbonate of sodium, *sodic carbonate*, is added to a hot solution of sulphate of magnesium,

*magnesian sulphate* ; carbonate and hydrate of magnesium are precipitated, and sulphate of sodium, *sodic sulphate*, is held in solution. The precipitate is washed with water by subsidation and decantation ; when all the sulphate of sodium is removed, water is added, and a stream of carbonic acid gas is passed through the solution until the hydrate and carbonate of magnesium are dissolved ; this solution upon cautious evaporation, yields carbonate of magnesium in crystals.

PROPERTIES.—A white crystalline neutral salt, slightly soluble in water, readily soluble in acids.

The carbonate of magnesia of the shops is simply the precipitate of carbonate and hydrate of magnesium formed when a solution of carbonate of sodium, *sodic carbonate*, is added to a solution of sulphate of magnesium, *magnesian sulphate*. The mixture is boiled, the precipitate well washed with water by decantation, and dried.

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## CHAPTER IV.

## METALS OF THE EARTHS.

## ALUMINIUM.

Symbol, Al; Equivalent, 27·26.

172. This element exists in immense quantities in the condition of oxide, as china, clay, shale, slate, &c.

PREPARATION (Deville's process).—Powdered cryolite, a mineral consisting of fluoride of aluminium and sodium, is mixed with chloride of sodium and sodium, introduced into a fire-clay crucible; the lid is luted on and heated in a furnace. After the lapse of some time the crucible is withdrawn from the fire, and allowed to cool; the mass is treated with water, which dissolves the fluoride and chloride of sodium, leaving crude aluminium. By fusion in a crucible under chloride of potassium (which salt is added to prevent the action of air upon the metal), at a high temperature, commercial aluminium is obtained.

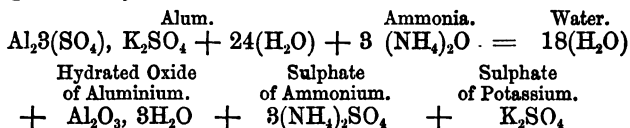
PROPERTIES.—A silvery white metal, not oxidized by contact with dry air, and water has no perceptible action upon it at ordinary temperatures. It is soluble in dilute acids, and possesses a low specific gravity (2·6); unites with oxygen to form oxide, and with acids forming salts. This metal has of late years been extensively employed as a substitute for silver and gold, in the manufacture of jewellery and other ornaments of dress, Gold bronze is formed by alloying aluminium with copper, gold, &c.

## OXIDE OF ALUMINIUM.

*Aluminic Oxide.*Symbol,  $\text{Al}_2\text{O}_3$ ; Equivalent, 102.52.

173. This compound exists in nature as corundum, sapphire, ruby, &c.

PREPARATION.—By adding to a solution of alum (sulphate of aluminium and potassium), ammonia; a gelatinous precipitate of hydrated oxide of aluminium is formed, thus:—



The hydrated oxide of aluminium is collected on a filter, washed with water, dried, and heated red hot; water is dissipated, leaving oxide of aluminium.

PROPERTIES.—A white solid, insoluble in water and cold dilute acids, soluble in hot concentrated acids forming salts, which have usually an acid reaction. This compound is also called alumina.

TESTS.—Neutral solutions of aluminium compounds give the following reactions:—

1. A solution of sulphide of hydrogen does not produce any precipitate.
2. A solution of sulphide of ammonium produces a white precipitate of hydrated oxide of aluminium.
3. A solution of carbonate of sodium gives a white precipitate of hydrated oxide of aluminium.
4. A solution of hydrate of potassium gives a white precipitate, soluble in excess, and reprecipitated by a solution of chloride of ammonium.
5. BLOWPIPE.—The solid compound, moistened with nitrate of cobalt, produces a blue colour.

## HYDRATED OXIDE OF ALUMINIUM.

*Aluminic Hydrate.*Symbol,  $\text{Al}_2\text{O}_3, 3(\text{H}_2\text{O})$ ; Equivalent, 156.52.

174. PREPARATION.—The preparation of this compound has been described under oxide of aluminium, par. 173.

PROPERTIES.—A white neutral solid, insoluble in water, easily soluble in dilute acids, and in a solution of hydrate of potassium or sodium.

### SULPHATE OF ALUMINIUM.

#### *Aluminic Sulphate.*

Symbol,  $\text{Al}_2\text{S}(\text{SO}_4) + 18(\text{H}_2\text{O})$ ; Equivalent, 666.52.

175. PREPARATION.—When hydrated oxide of aluminium is dissolved in dilute sulphuric acid, *hydric sulphate*, this compound is formed. It can also be prepared by the action of concentrated sulphuric acid upon china clay (impure oxide of aluminium). The liquor when crystallized yields this salt.

PROPERTIES.—A crystalline salt, soluble in water with an acid reaction to test paper. When strongly heated it suffers decomposition, oxide of aluminium being formed. This salt (patent alum) is extensively employed as a mordant in dyeing and calico printing.

### SULPHATE OF ALUMINIUM AND POTASSIUM.

#### (Potash Alum).

Symbol,  $\text{Al}_2\text{S}(\text{SO}_4), \text{K}_2\text{SO}_4, 24(\text{H}_2\text{O})$ ; Equivalent, 948.74.

176. PREPARATION.—This important double salt is prepared commercially from burned shale or china clay, by the action of hot concentrated sulphuric acid; sulphate of aluminium is thus formed. Sulphate, or ehloride of potassium, is added to the solution, and the liquor allowed to crystallize. Impure potash alum is obtained which is purified by repeated solution and crystallization.

PROPERTIES.—A white crystalline double salt, soluble in water, the solution possesses an acid reaction. Alum is extensively employed as a mordant or fixing agent by dyers, calico printers, colour makers, &c.

Sulphate of aluminium and ammonium (ammonia alum)	} $\text{Al}_2\text{S}(\text{SO}_4), (\text{NH}_4)_2\text{SO}_4, 24(\text{H}_2\text{O})$
Sulphate of aluminium and sodium (soda alum)	

These alums are prepared in the same manner as potash alum, simply substituting ammonium or sodium salts for sulphate or chloride of potassium.

Potash, soda, and ammonia alums, have the same crystalline form and chemical properties, and are employed commercially for the same practical purposes.

---

### ACETATE OF ALUMINIUM.

#### *Aluminic Acetate.*

Symbol,  $\text{Al}(\text{C}_2\text{H}_3\text{O}_2)_3$ ; Equivalent, 204.26.

177. PREPARATION.—Pure acetate of aluminium is prepared by dissolving hydrated oxide of aluminium, *aluminic hydrate*, in acetic acid, and crystallizing the solution.

Commercial acetate of aluminium is prepared by decomposing a solution of alum, by means of a solution of acetate of lead, *plumbic acetate*; a precipitate of sulphate of lead is formed, and acetate of aluminium and potassium remain in solution.

PROPERTIES.—A crystalline salt, soluble in water; the solution is decomposed by boiling, alumina being precipitated. A solution of this salt is extensively used as a mordant for the fixation of colours and dyes, by calico printers and dyers.

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### BERYLLIUM (Glucinium).

Symbol,  $\text{Be}$ ; Equivalent, 14.

178. This rare element exists in the emerald, beryl, and other minerals.

PREPARATION.—By decomposing chloride of beryllium, *beryllic chloride*, with sodium, assisted by heat, chloride of sodium, *sodic chloride*, and metallic beryllium are formed.

PROPERTIES.—A metal resembling aluminium, is not oxidised when exposed to the action of dry air; it unites with oxygen forming oxide of beryllium  $\text{Be}_2\text{O}_3$ , *beryllic oxide*, which

resembles the corresponding oxide of aluminium. It unites with acids to form salts.

Tests.—Solutions of beryllium salts are distinguished from those of aluminium by means of a solution of carbonate of ammonium, *ammonic carbonate*, which gives no precipitate when added (in excess) to a solution containing beryllium, until heat is applied; with the latter a solution of carbonate of ammonium produces an immediate white precipitate.

---

### YTTRIUM.

Symbol, Y; Equivalent, 64.4.

179. This element exists in small proportions in yttria, gadolanite, and other minerals.

The metal has been obtained by decomposing the double chloride of ammonium and yttrium.

It is not affected by exposure to the air, and is readily soluble in dilute acids. Hydrated salts of yttrium are of a rose colour.

---

### ERBIUM.

Symbol, E.

180. This element exists in very small proportions in a mineral named yttria.

Its properties have not yet been fully described, but Mosander states that it is a weak base, uniting with acids forming salts.

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### TERBIUM.

Symbol, Tr.

181. This rare element exists in combination with oxygen associated with yttrium and erbium in the mineral named yttria. It is a feeble base, uniting with acids forming salts. Nitrate of terbium, *terbic nitrate*, is a dark rose-coloured salt.

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### CERIUM.

Symbol, Ce; Equivalent, 92.

182. This element exists in a mineral called cerite. It unites with oxygen forming proto and sesqui oxides of cerium, and with acids to form red and yellow crystalline salts.

## LANTHANUM.

Symbol, Ln; Equivalent, 92·8.

183. This rare element exists in small proportions in the mineral cerite. It unites with oxygen, and with acids forming readily crystallizable salts.

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## DIDYMIUM.

Symbol, Di; Equivalent, 96.

184. This rare element exists, associated with lanthanum and cerium, in the mineral cerite. It unites with oxygen and with acids, forming red crystallizable salts.

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## ZIRCONIUM.

Symbol, Zr; Equivalent, 89·60.

185. This metal exists in the mineral zircon.

PREPARATION.—The metal may be prepared from the double fluoride of zirconium and potassium by the action of potassium; fluoride of potassium, *potassic fluoride*, and metallic zirconium are formed.

PROPERTIES.—A metal possessing a feeble lustre. When heated in contact with air it ignites, becoming converted into oxide. It unites with acids, forming colourless salts. The sesquioxide of zirconium, *zirconic oxide*, has a remarkable resemblance to the sesquioxide of aluminium, *aluminic oxide*.

---

## THORIUM.

Symbol, Th; Equivalent, 231·5.

186. This rare element exists in the mineral thorite. It can be prepared from the chloride of thorium by the action of potassium. It resembles aluminium, unites with oxygen, forming oxide ThO, and with the acids to form salts.

CHAPTER V.

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OXIDABLE METALS PROPER, WHOSE OXIDES FORM  
POWERFUL BASES.

## I R O N .

Symbol, Fe ; Equivalent, 56.

187. This element exists abundantly in nature as oxide, carbonate, sulphide, &c., &c. During the year 1864, 4,767,951 tons of pig iron were manufactured in the United Kingdom.

PREPARATION.—Clay iron ore (carbonate of iron with alumina silica, &c.) or hæmatite (oxides of iron) is mixed with coal, introduced into a furnace and a blast of hot air blown in to assist in raising the heat. The ore by this treatment is decomposed, carbide of iron and crude metallic iron are formed, also "slag" (silicate of alumina, iron, lime, &c.); the slag separates, and having a lower specific gravity than that possessed by the crude metal swims on the surface. The molten metal is allowed to flow from the furnace into moulds and it then constitutes "cast iron" of commerce.

By the operation of "puddling," which essentially consists in separating, by oxidation, the carbon, silicium, phosphorus, and sulphur of the cast iron, it is converted into wrought iron. The cast iron is melted in a reverberatory furnace with continuous agitation by stirring until the metal loses its fluidity : then strongly heated and after a time it is formed into masses or balls, which are submitted to the action of steam hammers, reheated, and passed through rollers, bars of "wrought iron" being produced.

PROPERTIES.—The physical properties and uses of iron are too well known to require a lengthy description. Pure iron has a white colour, and is difficultly fusible. When exposed to the action of dry air it oxidizes very slowly, but in contact with moist air it is speedily coated with oxide or “rust.” With oxygen it forms several compounds, three of which form definite salts. It is soluble in dilute acids forming crystallizable ferrous and ferric salts, which are largely employed as mordants by dyers and calico printers.

---

### OXIDES OF IRON.

Protoxide of iron	FeO ,	<i>Ferrous oxide.</i>
Sesquioxide	„ Fe <sub>2</sub> O <sub>3</sub> ,	<i>Ferric oxide.</i>
Black oxide	„ Fe <sub>3</sub> O <sub>4</sub> ,	
Ferric acid	FeO <sub>3</sub> ,	<i>Ferric anhydride.</i>

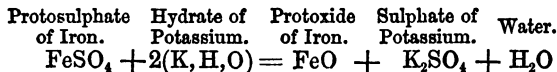
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### PROTOXIDE OF IRON.

*Ferrous Oxide.*

Symbol, FeO ; Equivalent, 72.

188. PREPARATION.—To a solution of protosulphate of iron, *ferrous sulphate*, a solution of hydrate of potassium, *potassic hydrate*, is added, hydrated protoxide of iron is formed, which upon boiling separates as a black precipitate. The precipitate is collected on a filter, washed and dried. The reaction which takes place may be explained, thus:—



PROPERTIES.—A black solid, insoluble in water, readily soluble in dilute acids, with which it forms salts of a green colour.

TESTS.—Acid solutions of protosalts of iron give the following reactions:—

1. A solution of sulphide of hydrogen gives no precipitate.
2. A solution of sulphide of ammonium gives a black precipitate of sulphide of iron.



3. A solution of ferrocyanide of potassium produces a pale blue precipitate of ferrocyanide of iron.
4. A solution of ferricyanide of potassium produces a dark blue precipitate (Turnbull's blue).

### PROTOSULPHATE OF IRON.

#### *Ferrous Sulphate.*

Symbol,  $\text{FeSO}_4 + 7(\text{H}_2\text{O})$ ; Equivalent, 278.

189. This salt is also called "green vitriol" and "copperas."

PREPARATION.—This salt is commercially prepared from iron pyrites ( $\text{FeS}_2$ ), by the action of air assisted by moisture. The sulphur unites with oxygen from the air forming sulphuric acid, which unites with the iron forming protosulphate of iron. The heaps of iron pyrites are watered and turned over every few days to assist oxidation; the mass is then treated with water, which dissolves out the sulphate of iron, &c. Upon evaporation the solution deposits crystals.

It is prepared in the laboratory by the action of dilute sulphuric acid upon iron filings, sulphate of iron is formed, hydrogen gas being evolved. The solution after filtration and evaporation, yields the salt in beautiful pale green crystals upon cooling.

PROPERTIES.—A green crystalline salt, soluble in water. It is extensively used as a mordant for the formation, and fixation of colours, by calico printers, dyers, &c., and is employed in the manufacture of writing ink; also by photographers as a developing agent, and as a reagent in the laboratory. By exposure to air, the salt becomes slowly converted into the ferric state.

### PROTOCHLORIDE OF IRON.

#### *Ferrous Chloride.*

Symbol,  $\text{FeCl}_2 + 4(\text{H}_2\text{O})$ ; Equivalent, 198.92.

190. PREPARATION.—Iron filings are dissolved in dilute hydrochloric acid, *hydric chloride*; protochloride of iron is

formed, and hydrogen gas is evolved. Upon concentrating the solution by evaporation it yields crystals of this salt.

PROPERTIES.—A green crystalline salt, soluble in water. When exposed to the air the solution gradually becomes converted into the ferric condition.

---

### PROTOSULPHIDE OF IRON.

#### *Ferrous Sulphide.*

Symbol,  $\text{FeS}$ ; Equivalent, 88.

191. PREPARATION.—When a bar of white hot iron is brought in contact with a roll of sulphur, they enter into combination, forming protosulphide of iron.

PROPERTIES.—A brown substance, possessing a metallic appearance, insoluble in water, soluble in dilute acids. It is employed for the preparation of sulphide of hydrogen gas by the action of water and dilute sulphuric acid, *hydric sulphate*, or hydrochloric acid, *hydric chloride*.

---

### PROTOIODIDE OF IRON.

#### *Ferrous Iodide.*

Symbol,  $\text{FeI} + 5(\text{H}_2\text{O})$ ; Equivalent, 899.76.

192. PREPARATION.—See the manufacture of iodide of potassium, *potassic iodide*, par. 85.

PROPERTIES.—A pale green crystalline salt, readily soluble in water; when exposed to the air it rapidly absorbs oxygen, becoming converted into the ferric condition. It is employed in medicine, and in the preparation of iodide of potassium.

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### PROTONITRATE OF IRON.

#### *Ferrous Nitrate.*

Symbol,  $\text{Fe}(\text{NO}_3)_2$ ; Equivalent, 180.

193. PREPARATION.—Dilute nitric acid, *hydric nitrate*, is allowed to act upon protosulphide of iron, *ferrous sulphide*, and

the solution kept cool. Upon evaporating the liquor in *vacuo*, the salt is deposited in crystals.

PROPERTIES.—A pale green crystalline salt, soluble in water. The salt when exposed to the air, becomes in a short time changed into the ferric state.

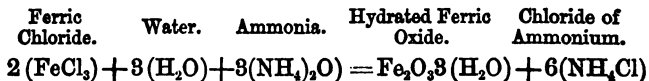
## SESQUIOXIDE OF IRON.

### *Ferric Oxide.*

Symbol,  $\text{Fe}_2\text{O}_3$  ; Equivalent, 160.

194. This oxide exists native as hæmatite.

PREPARATION.—Upon the addition of ammonia to a solution of ferric chloride, a yellowish brown precipitate of hydrated ferric oxide is formed, thus :—

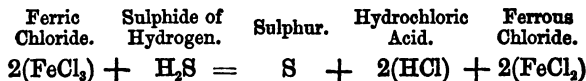


Upon heating the hydrated oxide, water is driven off, leaving ferric oxide.

PROPERTIES.—A red substance, insoluble in water, readily soluble in hydrochloric acid, *hydric chloride* ; with acids it forms salts, usually of a yellow or brown colour.

TESTS.—Acid solutions of ferric salts give the following reactions :—

1. A solution of sulphide of hydrogen produces a white precipitate of sulphur, at the same time reducing the iron to the ferrous state, thus :—



2. A solution of sulphide of ammonium, *ammonic sulphide*, produces a black precipitate of sulphide of iron.
3. A solution of ferrocyanide of potassium produces a dark blue precipitate (Prussian blue).

4. A solution of ferricyanide of potassium produces no blue colour.
- 

### SESQUICHLORIDE OF IRON.

#### *Ferric Chloride.*

Symbol,  $\text{FeCl}_3$ ; Equivalent, 162.38.

195. PREPARATION.—This salt is prepared by dissolving iron wire or filings in hydrochloric acid, with the addition of nitric acid, until the solution ceases to produce a blue colour with ferricyanide of potassium. The solution is cautiously evaporated to drive off the excess acid; upon cooling crystals of ferric chloride are deposited.

PROPERTIES.—An orange-yellow crystalline salt, soluble in water and alcohol. A solution of the salt is employed as a reagent in the laboratory.

---

### PERSULPHATE OF IRON.

#### *Ferric Sulphate.*

Symbol,  $\text{Fe}_2(\text{SO}_4)_3$ ; Equivalent, 400.

196. PREPARATION.—This salt is usually prepared from ferrous sulphate, by the action of nitric acid, *hydric nitrate*, and the addition of sulphuric acid, *hydric sulphate*. To a solution of ferrous sulphate, dilute sulphuric acid, and nitric acid are added; the solution is then heated until the whole of the ferrous salt is converted into ferric sulphate, and the excess of nitric acid expelled. Upon evaporation ferric sulphate is obtained.

PROPERTIES.—The salt combines with sulphates of potassium, sodium, and ammonium, forming double salts called “iron alums,” which have the same crystalline form as the “alumina alums.” The following are their formulæ.

Potassium iron alum.... $\text{Fe}_2(\text{SO}_4)_3, \text{K}_2\text{SO}_4, 24(\text{H}_2\text{O})$   
 Sodium iron alum..... $\text{Fe}_2(\text{SO}_4)_3, \text{Na}_2\text{SO}_4, 24(\text{H}_2\text{O})$   
 Ammonium iron alum.. $\text{Fe}_2(\text{SO}_4)_3, (\text{NH}_4)_2\text{SO}_4, 24(\text{H}_2\text{O})$

## BLACK OXIDE OF IRON.

Symbol,  $\text{Fe}_3\text{O}_4$ .

197. This oxide exists native as loadstone, magnetic oxide. Being incapable of forming salts or chemical compounds, the author is of opinion that this oxide is simply ferric and ferrous oxides in mechanical combination.

---

## FERRIC ACID.

*Ferric Anhydride.*Symbol,  $\text{FeO}_3$ .

198. This acid is only known in combination with bases; it has not yet been isolated.

Ferrate of potassium, *potassic ferrate*, may be prepared by heating in a crucible a mixture of ferric oxide and nitrate of potassium, *potassic nitrate*. The mass, upon cooling, is treated with ice cold water, to dissolve out the salt, which has a deep purple-red colour. The solution is decomposed by heat, with the liberation of oxygen, and precipitation of ferric oxide. With barium it forms a crimson insoluble ferrate of barium.

---

## MANGANESE.

Symbol, Mn; Equivalent, 55.14.

199. This element exists as oxide in the minerals, varcite, manganite, braunite, pyrolusite, &c.

PREPARATION.—The metal is often prepared by decomposing fluoride of manganese and sodium by the action of sodium, assisted with heat.

PROPERTIES.—When prepared by the above process it resembles iron or steel in its leading physical properties; it is readily soluble in dilute acids. With oxygen it forms several oxides, some of which possess basic, and others acid characters; it also enters into combination with acids forming salts.

## OXIDES OF MANGANESE.

Protoxide of manganese... $\text{MnO}$  *Manganous Oxide.*  
 Sesquioxide of manganese... $\text{Mn}_2\text{O}_3$  *Manganic Oxide.*  
 Binoxide of manganese ... $\text{MnO}_2$  *Manganic Peroxide.*  
 Manganic acid..... $\text{MnO}_3$  *Manganic Anhydride.*  
 Permanganic acid ..... $\text{Mn}_2\text{O}_7$  *Permanganic Adhydride.*

---

## PROTOXIDE OF MANGANESE.

*Manganous Oxide.*

Symbol,  $\text{MnO}$  ; Equivalent, 71.14.

200. PREPARATION.—A stream of hydrogen gas is passed through a white hot fire-clay tube containing carbonate of manganese, *manganous carbonate* ; carbonic acid gas is liberated and protoxide of manganese is formed.

PROPERTIES.—A green coloured solid, soluble in acids, forming rose-coloured salts.

TESTS.—Acid solutions of protosalts of manganese give the following reactions :—

1. A solution of sulphide of hydrogen produces no reaction.
  2. A solution of sulphide of ammonium produces a pale buff coloured precipitate of sulphide of manganese.
  3. Blowpiped with borax on platinum wire, an amethyst coloured bead is produced.
  4. Blowpiped with nitrate, and carbonate of potassium on platinum foil, a green mass of manganate of potassium is formed.
- 

## CHLORIDE OF MANGANESE.

*Manganous Chloride.*

Symbol,  $\text{MnCl}_2$  ; Equivalent, 126.06.

201. PREPARATION.—Commercial binoxide of manganese, which consists of manganic peroxide with oxides of iron, &c., is dissolved in hydrochloric acid, *hydric chloride* ; chlorides of

manganese and iron are produced, and chlorine gas is given off. The solution is evaporated to dryness, and heated in a crucible, the ferric chloride suffers decomposition, being partially volatilized, and the remainder being converted into insoluble oxide. When cool, the mass is treated with water, to dissolve out the chloride of manganese, which can be obtained in the solid form by evaporating the solution.

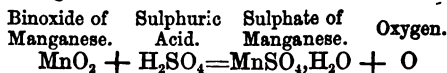
PROPERTIES.—A rose pink crystalline salt, soluble in water and alcohol.

### SULPHATE OF MANGANESE.

#### *Manganous Sulphate.*

Symbol,  $\text{MnSO}_4 + 7(\text{H}_2\text{O})$ ; Equivalent, 277·14.

202. PREPARATION.—This salt is formed when binoxide of manganese, *manganic peroxide*, is digested with sulphuric acid, *hydric sulphate*; impure sulphate of manganese is formed, and oxygen gas is given off, thus:—



The whole is evaporated to dryness, and heated red hot to decompose any ferric sulphate present; the mass after cooling is digested with hot water, the solution filtered and set aside to crystallize.

PROPERTIES.—A rose coloured crystalline salt, soluble in water. This and the last mentioned salt were formerly extensively used by dyers and calico printers for the production of manganese brown dyes.

### SESQUIOXIDE OF MANGANESE.

#### *Manganic Oxide.*

Symbol,  $\text{Mn}_2\text{O}_3$ ; Equivalent, 156·28.

203. This oxide exists native as braunite, &c.

It is a weak base but forms with sulphuric acid and sulphate of potassium, a crystalline double salt named "manganese alum,"  $\text{Mn}_2(\text{SO}_4)_3, \text{K}_2\text{SO}_4, 24(\text{H}_2\text{O})$ .

The oxide is formed when binoxide of manganese is heated red hot in the manufacture of oxygen gas, see par. 1.

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## BINOXIDE OF MANGANESE.

### *Manganic Peroxide.*

Symbol,  $\text{MnO}_2$ ; Equivalent, 142.28.

204. This important oxide exists native as pyrolusite, black oxide, &c., in large quantities in Germany, and Wales. It is largely employed by our chemical manufacturers for the preparation of chlorine and oxygen gases, and in glass making.

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#### ESTIMATION OF THE PER CENTAGE OF PURE PEROXIDE OF MANGANESE IN A SAMPLE OF "MANGANESE."

205. The commercial value of manganese can be determined by the following process, which is based upon the property that binoxide of manganese, *manganic peroxide*, possesses of converting protosulphate of iron, *ferrous sulphate*, into the ferric condition when heated with hydrochloric acid, *hydric chloride*.

100 grains of pure binoxide of manganese effects the conversion of 684 grains of pure crystallized protosulphate of iron.

A standard solution of acid chromate of potassium, *potassic dichromate*, must be prepared in order to determine the amount of ferrous sulphate that remains unaltered; from which data the amount of ferrous sulphate, converted by the binoxide of manganese, into the ferric state can be calculated. For this purpose, 179 grains of pure acid chromate of potassium are dissolved in 10 alkalimeters (10,000 grains) of water; 100 measures of this standard solution are capable of converting 100 grains of pure crystallized ferrous sulphate into the condition of a ferric salt.

Twenty-five grains of the finely powdered sample of binoxide of manganese, and 158.5 grains of pure crystallized protosulphate of iron are weighed, introduced into a flask with about an



ounce and a half of hydrochloric acid, and a gentle heat applied. In about half an hour the manganese will have completely dissolved, and the silica, if present, should be white.

If a drop of the solution when tested with ferricyanide of potassium, *potassic ferricyanide*, gives a blue colour: then the standard solution of acid chromate of potassium (the preparation of which has already been described) is added cautiously from the alkalimeter until a drop ceases to produce a blue colour with ferricyanide of potassium. The operation is then complete, and the number of measures of the standard solution used are to be noted.

**EXAMPLE.**—Twenty-five grains of a sample of binoxide of manganese, and 158.5 grains of pure crystallized ferrous sulphate were taken. After decomposition by hydrochloric acid, 15 measures of the standard acid, chromate of potassium, were added to change the remaining (unconverted) ferrous salt.

Fifteen measures of the standard chrome solution being equivalent to 15 grains of pure crystallized ferrous sulphate, this amount must be subtracted from the number of grains weighed, viz:—158.5, which leaves 143.5, the amount of ferrous salt converted by the 25 grains of binoxide of manganese taken.

As 684 grains of pure crystallized ferrous sulphate are equal to 100 grains of binoxide of manganese, so are 143.5 grains of ferrous sulphate equivalent to 22.63 grains of real binoxide of manganese contained in 25 grains, and this quotient, 22.63, multiplied by 4, will give the percentage of binoxide contained in the sample under examination:—

$$\text{As } 684 : 100 :: 143.5 : x = 22.63.$$

$$22.63 \times 4 = 90.52 \text{ per cent of binoxide.}$$

## MANGANIC ACID.

### *Manganic Anhydride.*

Symbol,  $\text{MnO}_3$ ; Equivalent, 108.14.

206. This acid has not been isolated. It may be obtained in combination with potassium in the following manner:—Finely powdered binoxide of manganese is mixed with nitrate

or chlorate of potassium, and hydrate of potassium, introduced into a crucible, and heated in a furnace for a short time. The mass is then allowed to cool, and is lixiviated; the solution, upon evaporation in vacuo, deposits manganate of potassium, *potassic manganate*.

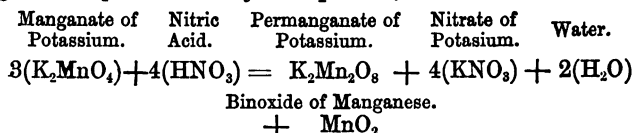
Manganate of potassium is a green crystalline salt, soluble in water; upon the addition of dilute nitric acid the solution becomes of a beautiful purple-red colour, arising from the formation of permanganate of potassium, *potassic permanganate*. The salt is often called "mineral chameleon."

### PERMANGANIC ACID.

#### *Permanganic Anhydride.*

Symbol,  $\text{Mn}_2\text{O}_7$ ; Equivalent, 222.28.

207. This acid has not been isolated. It may be obtained in combination with potassium by the following process:—Manganate of potassium is dissolved in water, and dilute nitric acid added until the green colour is completely destroyed. The liquor is then filtered through asbestos or powdered glass; upon evaporation, the salt is deposited in crystals. The reaction which takes place between the nitric acid and the manganate of potassium may be expressed, thus:—



Permanganate of potassium crystallizes in beautiful purple red crystals; the solution in water is immediately decolourized by organic matter, and reducing agents, and has of late years been largely introduced for volumetric analysis.

### CHROMIUM.

Symbol, Cr; Equivalent, 58.5.

208. This metal exists as oxide in combination with protoxide of iron in the mineral, chrome iron ore.

**PREPARATION.**—Deville has prepared chromium by reducing the sesquioxide with charcoal, in a lime crucible at a high temperature.

**PROPERTIES.**—The metallic chromium obtained by the above process is extremely hard, difficultly fusible, soluble in dilute hydrochloric and sulphuric acids, almost insoluble in nitric acid. It forms oxides with oxygen; and with the acids, salts.

---

### OXIDES OF CHROMIUM.

Protoxide of chromium	CrO	<i>Chromous oxide.</i>
Sesquioxide	„ $\text{Cr}_2\text{O}_3$	<i>Chromic oxide.</i>
Chromic acid	$\text{CrO}_3$	<i>Chromic anhydride.</i>
Perchromic acid	$\text{Cr}_2\text{O}_7$	<i>Perchromic anhydride.</i>

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### PROTOXIDE OF CHROMIUM.

*Chromous Oxide.*

Symbol, CrO; Equivalent, 69.5.

**209. PREPARATION.**—If a dilute solution of hydrate of potassium, *potassic hydrate*, is added to a dilute solution of protochloride of chromium, *chromous chloride*; a precipitate of chromous oxide is formed, which may be collected on a filter, washed, and dried.

**PROPERTIES.**—A reddish brown coloured powder, soluble in acids, forming unstable salts of a blue colour, which possess a great affinity for oxygen.

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### SESQUIOXIDE OF CHROMIUM.

*Chromic Oxide.*

Symbol,  $\text{Cr}_2\text{O}_3$ ; Equivalent, 155.

**210. PREPARATION.**—The anhydrous sesquioxide of chromium is obtained by heating red hot a mixture of acid chromate of potassium and boracic acid. The mass, upon cooling, is treated with water, and the insoluble oxide collected on a filter, washed with water, and dried.

PROPERTIES.—A beautiful green crystalline compound, difficultly soluble in acids.

The hydrated sesquioxide is prepared by adding liquid ammonia to a solution of sesquichloride of chromium, *chromic chloride*, the precipitate is collected on a filter, washed, and cautiously dried.

PROPERTIES.—A bluish green powder, soluble in dilute acids, forming green or purple coloured salts.

TESTS.—Acid solutions of chromic salts give the following reactions with the reagents :—

1. A solution of sulphide of hydrogen produces no precipitate.
2. A solution of sulphide of ammonium produces a bluish green precipitate of hydrated sesquioxide of chromium.
3. A solution of carbonate of sodium, *sodic carbonate*, produces a similar reaction.
4. Blowpiped in the reduction flame with borax on platinum wire, it forms a green coloured bead.

## SESQUISULPHATE OF CHROMIUM.

### *Chromic Sulphate.*

Symbol,  $\text{Cr}_2(\text{SO}_4)_3$ ; Equivalent, 395.

211. PREPARATION.—By dissolving the hydrated sesquioxide in dilute sulphuric acid, *hydric sulphate*. Upon evaporation the solution deposits crystals of the salt.

PROPERTIES.—A ruby-red crystalline salt, soluble in water, forms with sulphates of potassium, sodium, and ammonium double salts, called “chrome alums.”

Potash chrome alum..... $\text{Cr}_2(\text{SO}_4)_3$ ,  $\text{K}_2\text{SO}_4$ ,  $24(\text{H}_2\text{O})$   
 Soda chrome alum ..... $\text{Cr}_2(\text{SO}_4)_3$ ,  $\text{Na}_2\text{SO}_4$ ,  $24(\text{H}_2\text{O})$   
 Ammonia chrome alum..... $\text{Cr}_2(\text{SO}_4)_3$ ,  $(\text{NH}_4)_2\text{SO}_4$ ,  $24(\text{H}_2\text{O})$

These alums resemble in crystalline form the corresponding alumina and iron alums.

## SESQUICHLORIDE OF CHROMIUM.

*Chromic Chloride.*

Symbol,  $\text{CrCl}_3$  ; Equivalent, 159.88.

212. PREPARATION.—The anhydrous salt is prepared by passing chlorine gas over a red hot mixture of chromic oxide, and charcoal contained in a porcelain tube. The compound sublimes into the cool part of the tube and may be collected.

PROPERTIES.—A peach coloured crystalline salt, insoluble in acids.

The hydrated sesquichloride of chromium is prepared by dissolving the hydrated sesquioxide in dilute hydrochloric acid, and crystallizing the solution.

PROPERTIES.—A crystalline salt, dissolves in water forming a dark green coloured solution.

## CHROMIC ACID.

*Chromic Anhydride.*

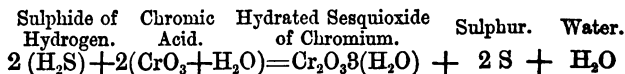
Symbol,  $\text{CrO}_3$  ; Equivalent, 101.5.

213. PREPARATION.—Concentrated sulphuric acid is added to a saturated solution of acid chromate of potassium, heat is evolved ; chromic acid is deposited in crystals upon cooling. The crystals are to be collected and dried upon a piece of porous brick or tile ; a bell jar must be placed over the whole to prevent the absorption of moisture from the air. By recrystallization pure chromic acid is obtained.

PROPERTIES.—A scarlet crystalline acid solid, deliquescent ; with water it forms an orange yellow solution, unites with the bases forming chromates, all of which are coloured salts, and many are employed as paints, and pigments.

TESTS.—Solutions of chromic acid give the following reactions :—

1. A solution of sulphide of hydrogen produces a whitish precipitate of sulphur, the chromic acid being reduced to the condition of chromic oxide, thus :—



- 2.—A solution of carbonate of sodium, *sodic carbonate*, produces no precipitate.
- 3.—A solution of acetate of lead, *plumbic acetate*, produces a yellow precipitate of chromate of lead.
- 4.—Blowpiped with borax in the reduction flame—green colour.

Chromate of Potassium, Bichromate of Potassium.—For a description of the manufacture, &c. of these salts, see pars. 87 and 88.

Chromate of Lead.—See par. 249.

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### PERCHROMIC ACID.

*Perchromic Anhydride.*

Symbol,  $\text{Cr}_2\text{O}_7$ ; Equivalent, 219.

214. According to Barrasville this unstable acid may be obtained by the action of a solution of binoxide of hydrogen upon a solution of chromic acid. The blue liquor formed is treated with ether, which dissolves the perchromic acid.

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### NICKEL.

Symbol, Ni; Equivalent, 59.

215. This element occurs in combination with sulphur and arsenic in the minerals, *nickelglanz*, *kupfernickel*, &c., in Sweden and Westphalia.

PREPARATION.—A mixture of oxalate of nickel, *nickelic oxalate*, and carbon is introduced into a crucible and strongly heated; the oxalate is decomposed, being reduced to the metallic state.

PROPERTIES.—A silvery white metal, oxidizes very slowly when exposed to the air. It is principally used by the manufacturers of imitation silver wares for the preparation of nickel German silver, and other alloys. It is readily soluble in strong acids; unites with oxygen forming oxide, and with the acids to form salts, which are usually of a green colour.

## OXIDES OF NICKEL.

Protoxide of Nickel  $\text{NiO}$ , *Nickelic oxide*.

Sesquioxide „  $\text{Ni}_2\text{O}_3$ , *Nickelic peroxide*.

## PROTOXIDE OF NICKEL.

*Nickelic oxide*.

Symbol,  $\text{NiO}$  ; Equivalent, 75.

216. PREPARATION.—A solution of hydrate of potassium, *potassic hydrate*, is added to a solution of sulphate of nickel, *nickelic sulphate*, hydrated oxide of nickel is precipitated, and sulphate of potassium remains in solution. The green hydrate is collected, washed, dried, and strongly heated.

PROPERTIES.—A grey powder, soluble in acids, forming green salts which become yellow when rendered anhydrous by the action of heat.

TESTS.—Mineral acid solutions of nickel give the following reactions with the reagents:—

1. A solution of sulphide of hydrogen produces no reaction.
2. A solution of sulphide of ammonium produces a black precipitate of sulphide of nickel, *nickelic sulphide*.
3. A solution of carbonate of sodium, *sodic carbonate*, produces an apple green precipitate of carbonate of nickel.
4. A solution of carbonate of ammonium, *ammonic carbonate*, produces an apple green precipitate, soluble in excess forming a blue solution.

## NITRATE OF NICKEL.

*Nickelic Nitrate*.

Symbol,  $\text{Ni}(\text{NO}_3)_2$  ; Equivalent, 188.

217. Nickel is digested with nitric acid, *hydric nitrate*, the green solution upon evaporation yields the salt.

PROPERTIES.—A green crystalline salt, soluble in water.

## SULPHATE OF NICKEL.

*Nickelic Sulphate.*

Symbol,  $\text{NiSO}_4 + 7(\text{H}_2\text{O})$ ; Equivalent, 281.

218. PREPARATION.—Oxide of nickel is dissolved in sulphuric acid, *hydric sulphate*, and the salt obtained by crystallization.

PROPERTIES.—A green salt, soluble in water, unites with sulphates of potassium and ammonium forming crystalline double salts.

## CHLORIDE OF NICKEL.

*Nickelic Chloride.*

Symbol,  $\text{NiCl}_2 + 9(\text{H}_2\text{O})$ ; Equivalent, 291.92.

219. PREPARATION.—Oxide of nickel is dissolved in hydrochloric acid, and the solution crystallized.

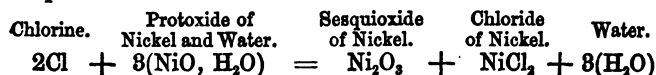
PROPERTIES.—A green salt; when rendered anhydrous it becomes yellow.

## SESQUIOXIDE OF NICKEL.

*Nickelic Peroxide.*

Symbol,  $\text{Ni}_2\text{O}_3$ ; Equivalent, 166.

220. PREPARATION.—Chlorine gas is passed through water in which the hydrated protoxide is suspended; chloride and sesquioxide of nickel are formed thus:—



PROPERTIES.—A black solid, decomposed by heat with the evolution of oxygen, and formation of protoxide.

## COBALT.

Symbol,  $\text{Co}$ ; Equivalent, 59.

221. This element occurs in combination with sulphur and arsenic as kobaltglanz, speiskobalt, and other minerals.



PREPARATION.—The metal may be prepared from oxalate of cobalt, *cobaltic oxalate*, by similar means to those adopted for the preparation of nickel.

PROPERTIES.—A metal resembling iron; when exposed to dry air it does not tarnish; it is readily soluble in concentrated acids, but is scarcely acted upon by dilute hydrochloric and sulphuric acids. It combines with oxygen forming two oxides, and unites with acids forming rose coloured salts. Oxides of cobalt are employed in porcelain painting, glass staining, &c. "Smalts" and cobalt "ultramarine"; these blue pigments are preparations of cobalt.

---

### OXIDES OF COBALT.

Protoxide of Cobalt  $\text{CoO}$  *Cobaltic Oxide*.

Sesquioxide of Cobalt  $\text{Co}_2\text{O}_3$  *Cobaltic Peroxide*.

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### PROTOXIDE OF COBALT.

*Cobaltic Oxide*.

Symbol,  $\text{CoO}$ ; Equivalent, 75.

222. PREPARATION.—A solution of carbonate of sodium is added to a solution of nitrate or chloride of cobalt; the precipitate is collected, dried, and heated red hot.

PROPERTIES.—A grey powder, soluble in acids, forming rose-pink coloured salts.

TESTS.—Mineral acid solutions of cobalt give the following reactions with the reagents:—

1. A solution of sulphide of hydrogen produces no precipitate.
2. A solution of sulphide of ammonium produces a black precipitate of sulphide of cobalt, *cobaltic sulphide*.
3. A solution of carbonate of sodium produces a pink precipitate of carbonate and hydrate of cobalt.
4. A solution of cyanide of potassium, *potassic cyanide*, produces a precipitate, soluble in excess of the reagent; the solution after warming for a few minutes does *not* give a precipitate upon the addition of hydrochloric acid.

NOTE.—This test readily distinguishes solutions of cobalt from those of nickel.

5. Blowpiped on platinum wire with borax, gives a blue glass.
- 

### NITRATE OF COBALT.

#### *Cobaltic Nitrate.*

Symbol,  $\text{Co}(\text{NO}_3)_2 + 3(\text{H}_2\text{O})$ ; Equivalent, 237.

223. PREPARATION.—Cobalt is dissolved in dilute nitric acid, and the salt crystallized.

PROPERTIES.—A rose coloured salt, soluble in water. The solution is employed as a blowpipe reagent for the detection of zinc, aluminium, magnesia, &c.

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### CHLORIDE OF COBALT.

#### *Cobaltic Chloride.*

Symbol,  $\text{CoCl}_2$ ; Equivalent, 129.92.

224. PREPARATION.—Oxide of cobalt is dissolved in hydrochloric acid, *hydric chloride*; the liquor upon evaporation deposits crystals of the hydrated chloride of cobalt which are of a rose colour. If however, the solution be rendered highly concentrated by evaporation, blue crystals of anhydrous chloride of cobalt are formed.

---

### SESQUIOXIDE OF COBALT.

#### *Cobaltic Peroxide.*

Symbol,  $\text{Co}_2\text{O}_3$ ; Equivalent, 166.

225. PREPARATION.—A solution of hypochlorite of calcium is mixed with a solution of nitrate of cobalt, and the precipitate collected and dried.

PROPERTIES.—A black powder, insoluble in water, soluble in acids, being decomposed, and forming protosalts.

## ZINC.

Symbol, Zn ; Equivalent, 65·06.

226. This element exists as carbonate (calamine) and sulphide (zinc blende).

PREPARATION.—The metal is commercially prepared from calamine in the following manner:—The ore is first roasted, then mixed with carbon or coke, and distilled at a high temperature in fire-clay retorts. The impure metal volatilizes and is condensed in receivers. By redistillation it may be obtained almost pure.

PROPERTIES.—A bluish white crystalline metal ; when exposed to the air it is very slowly oxidized. When strongly heated in contact with oxygen or air, it burns with a greenish light, becoming converted into oxide ; it is soluble in dilute acids, forming white salts. Zinc is extensively employed in the manufacture of brass and other alloys, also as an electro-negative metal for galvanic batteries.

---

OXIDE OF ZINC.*Zincic Oxide.*

Symbol, ZnO ; Equivalent, 81·06.

227. PREPARATION.—By heating carbonate of zinc, *zincic carbonate*, red hot ; carbonic acid gas is set free, and oxide of zinc is left in the crucible. It is also formed when zinc is burned in air.

PROPERTIES.—A white powder, insoluble in water, readily soluble in dilute acids, with which it forms salts. When heated it becomes of a yellow colour, but changes to its original colour upon cooling. It is employed by painters as a substitute for white lead, and is called zinc “permanent white.”

TESTS.—Acid solutions of zinc give the following reactions with the reagents :—

1. A solution of sulphide of hydrogen produces no precipitate.
2. A solution of sulphide of ammonium produces a white precipitate of sulphide of zinc, *zincic sulphide*.

3. A solution of carbonate of ammonium, *ammonic carbonate*, produces a white precipitate of carbonate of zinc, which is soluble in excess of the reagent.

Note.—This reaction distinguishes solutions of zinc from those of alumina.

4. The solid blowpiped with a drop of nitrate of cobalt, *cobaltic nitrate*, gives a green mass.
- 

### SULPHATE OF ZINC.

#### *Zincic Sulphate.*

Symbol,  $\text{ZnSO}_4 + 7(\text{H}_2\text{O})$ ; Equivalent, 287.06.

228. PREPARATION.—Granulated zinc is dissolved in dilute sulphuric acid, *hydric sulphate*; after evaporation the liquor deposits the salt upon cooling.

PROPERTIES.—A crystalline salt resembling sulphate of magnesium, *magnesian sulphate*, soluble in water, and is extensively used in medicine. By the trade this salt is called “white vitriol.”

---

### CHLORIDE OF ZINC.

#### *Zincic Chloride.*

Symbol,  $\text{ZnCl}_2$ ; Equivalent, 135.98.

229. PREPARATION.—Granulated zinc is dissolved in dilute hydrochloric acid; hydrogen gas is evolved and chloride of zinc formed. The liquor is evaporated until it solidifies upon cooling.

PROPERTIES.—A white deliquescent solid, employed in medicine.

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### INDIUM.

Symbol, In; Equivalent, 71.8.

230.—This element has been discovered by Reich and Reichter, in samples of Freiburg zinc; C. Winkler found

0.0448 per cent. of indium present in a sample he examined. The metal resembles platinum in appearance, it is soft and malleable, and oxidizes only slightly when exposed to the air. When heated red hot it ignites, burning with a violet blue flame; it is soluble in dilute acid, and possesses a specific gravity of about 7.36.

---

### CADMIUM.

Symbol, Cd ; Equivalent 112.

231.—This element occurs associated with zinc in Silesia.

PREPARATION.—When roasted calamine is distilled with charcoal for the manufacture of zinc ; cadmium being more volatile than zinc, volatilizes and is condensed in the receiver along with the first portions of zinc that distil over. The cadmium may be purified by redistillation.

PROPERTIES.—A silvery white metal, tarnishes but slightly when exposed to the air, soluble in nitric acid, scarcely acted upon by dilute hydrochloric or sulphuric acids. It forms an oxide with oxygen, and most of its salts are colourless.

---

### OXIDE OF CADMIUM.

#### *Cadmic Oxide.*

Symbol, CdO ; Equivalent, 128.

232. PREPARATION.—Nitrate of cadmium is strongly heated; it is decomposed, and oxide of cadmium is formed.

PROPERTIES.—A yellowish coloured powder, soluble in acids forming salts.

TESTS.—Acid solutions of cadmium give the following reactions :—

1. A solution of sulphide of hydrogen produces a yellow precipitate of sulphide of cadmium.
2. A solution of sulphide of ammonium produces a similar reaction to the last, the precipitate is insoluble in an excess of the reagent.
3. A solution of carbonate of ammonium gives a white precipitate, soluble in excess of the reagent.

## NITRATE OF CADMIUM.

*Cadmic Nitrate.*

Symbol,  $\text{Cd}(\text{NO}_3)_2$ ; Equivalent, 236.

233. PREPARATION.—Cadmium is dissolved in hot nitric acid, and the solution allowed to crystallize.

PROPERTIES.—A crystalline salt, readily soluble in water.

---

## SULPHATE OF CADMIUM.

*Cadmic Sulphate.*

Symbol,  $\text{CdSO}_4$ ; Equivalent, 208.

234. PREPARATION.—Oxide of cadmium is digested with dilute sulphuric acid, and the liquor filtered and crystallized.

PROPERTIES.—A colourless salt, very soluble in water.

---

## URANIUM.

Symbol, U; Equivalent, 120.

235. This metal occurs in the minerals, pitch-blende, and uranite.

PREPARATION.—The metal is obtained by decomposing the protochloride by means of potassium at a white heat; chloride of potassium, *potassic chloride*, and uranium are formed. Upon cooling, the chloride of potassium is separated by treatment with water.

PROPERTIES.—A white metal, is scarcely effected by exposure to the air. When strongly heated in contact with air it inflames, becoming converted into protoxide; with acids it forms two series of compounds, uranous and uranic salts. The oxides of uranium are employed in glass and porcelain painting and staining.

---

## OXIDES OF URANIUM.

Protoxide of Uranium .....  $\text{U O}$  ..... *Uranous oxide*.  
 Sesquioxide of Uranium.....  $\text{U}_2\text{O}_3$  ..... *Uranic oxide*.

## PROTOXIDE OF URANIUM.

*Uranous Oxide.*Symbol,  $\text{UO}$  ; Equivalent, 186.

236.—**PREPARATION.**—When a stream of hydrogen is passed over red hot sesquioxide, this oxide is formed.

**PROPERTIES.**—A dark brown powder, soluble in acids, forming dark green crystalline salts. When dissolved in nitric acid, sesquinitrate is formed.

## SESQUIOXIDE OF URANIUM.

*Uranic Oxide.*Symbol,  $\text{U}_2\text{O}_3$  ; Equivalent, 288.

237. **PREPARATION.**—A solution of hydrate of potassium is added to a solution of sesquinitrate of uranium, and the yellow precipitate of hydrated sesquioxide of uranium formed is collected, washed, and dried. The resulting sesquioxide always contains a portion of undecomposed hydrates of uranium and potassium. The pure sesquioxide is obtained by heating nitrate of uranium.

**PROPERTIES.**—A yellow powder, soluble in acids, forming yellow salts. When heated it is partially decomposed, a mixture of proto and sesquioxide of uranium being formed which from its dark colour has been named black oxide.

**TESTS.**—Acid solutions of per salts of uranium give the following reactions :—

1. A solution of sulphide of hydrogen produces no precipitate.
2. A solution of sulphide of ammonium produces a dark brown precipitate of sulphide of uranium.
3. Liquid ammonia gives an orange yellow precipitate, insoluble in excess.
4. A solution of carbonate of ammonium produces a yellow precipitate, soluble in excess. This reaction readily distinguishes and separates sesquioxide of uranium from the ferric salts.

## NITRATE OF URANIUM.

*Uranic Nitrate.*

Symbol,  $\text{UNO}_4 + 8(\text{H}_2\text{O})$ ; Equivalent, 252.

238. PREPARATION.—Uranium, or oxide of uranium, is dissolved in hot nitric acid; the liquor upon cooling yields the salt.

PROPERTIES.—A yellow crystalline salt, soluble in water.

---

## B I S M U T H.

Symbol, Bi; Equivalent, 210.

239.—This metal exists native in the metallic state, also as oxide and sulphide.

PROPERTIES.—A heavy crystalline metal, possessing a yellowish white colour; when exposed to the air it oxidizes slowly. With oxygen it forms two oxides. It is soluble in dilute nitric acid, but only slightly so in dilute hydrochloric and sulphuric acids.

A mixture of five parts of lead, three of tin, and eight of bismuth form the alloy called “fusible metal,” which melts at a temperature of about 200 degrees Fahrenheit.

---

## OXIDES OF BISMUTH.

Teroxide of bismuth  $\text{Bi}_2\text{O}_3$ , *Bismuthic Oxide*.

Bismuthic acid  $\text{Bi}_2\text{O}_5$ , *Bismuthic Anhydride*.

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## TEROXIDE OF BISMUTH.

*Bismuthic Oxide.*

Symbol,  $\text{Bi}_2\text{O}_3$ ; Equivalent, 468.

240. PREPARATION.—Obtained by igniting nitrate of bismuth, *bismuthic nitrate*.

PROPERTIES.—A yellow powder, soluble in acids.



TESTS.—Acid solutions of bismuth give the following reactions :—

1. A solution of sulphide of hydrogen gives a black precipitate of sulphide of bismuth, *bismuthic sulphide*.
2. Water decomposes concentrated solutions of bismuth salts with the formation of a white precipitate of a basic salt.
3. Dilute sulphuric acid produces no precipitate.

Note.—This reaction distinguishes solutions of bismuth from those of lead.

### NITRATE OF BISMUTH.

#### *Bismuthic Nitrate.*

Symbol,  $\text{Bi}(\text{NO}_3)_3 + 10 (\text{H}_2\text{O})$ ; Equivalent, 576.

241. PREPARATION.—Powdered bismuth is dissolved in a mixture of equal parts of nitric acid and water, with the assistance of a gentle heat. Upon cooling the salt is deposited.

PROPERTIES.—A colourless crystalline salt, is decomposed by water forming a white insoluble basic nitrate.

### BISMUTHIC ACID.

#### *Bismuthic Anhydride.*

Symbol,  $\text{Bi}_2\text{O}_3$ ; Equivalent, 500.

242. PREPARATION.—Chlorine gas is passed through a solution of hydrate of potassium, *potassic hydrate*, in which tetroxide of bismuth is mechanically suspended by agitation. Chloride of potassium, *potassic chloride*, and bismuthic acid are formed. The insoluble acid is collected on a filter, washed with dilute nitric acid, then with water, and lastly dried.

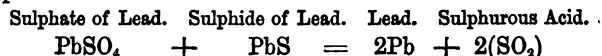
PROPERTIES.—A reddish powder, combines with bases forming salts.

### LEAD.

Symbol, Pb; Equivalent, 207.14.

243. This element exists as sulphide (galena), carbonate, &c.

**PREPARATION.**—Sulphide of lead (galena) is roasted in a reverberatory furnace; a portion of it is converted into sulphate by the oxidizing power of the air; the heat, after a time, is increased, when sulphurous acid gas is liberated, and impure metallic lead is formed. The reaction which takes place between the sulphate and sulphide of lead may be explained thus:—



**PROPERTIES.**—A soft, bluish-white, heavy metal; it oxidizes when exposed to the air; it is readily soluble in nitric acid; but is scarcely acted upon by sulphuric or hydrochloric acids. With oxygen it forms three distinct oxides, and combines with acids forming salts. The various useful applications to which metallic lead is applied are too well known to require description. It forms a number of important compounds, such as “chrome yellow,” “white lead,” “sugar of lead,” “litharge,” “red lead,” &c., which are extensively used in the preparation of paints, colours, &c.

The author considers “red lead” as simply a mechanical mixture of the proto and peroxide, and not a chemical compound.

### OXIDES OF LEAD.

Suboxide of lead  $\text{Pb}_2\text{O}$ , *Plumbous oxide*.

Protoxide of lead  $\text{PbO}$ , *Plumbic oxide*.

Binoxide of lead  $\text{PbO}_2$ , *Plumbic peroxide*.

### SUBOXIDE OF LEAD.

*Plumbous Oxide.*

Symbol,  $\text{Pb}_2\text{O}$ ; Equivalent, 480.28.

**244. PREPARATION.**—When protoxide of lead is heated red hot, impure suboxide is formed.

**PROPERTIES.**—A grey coloured solid; when moistened with water and exposed to the air, it absorbs oxygen. Treated with acids, it dissolves forming plumbic salts.

## PROTOXIDE OF LEAD.

*Plumbic Oxide.*

Symbol,  $\text{PbO}$  ; Equivalent, 228·14.

245. This oxide is commonly called litharge.

PREPARATION.—If carbonate of lead, *plumbic carbonate*, be heated, it is decomposed, carbonic acid gas is set free, and protoxide of lead remains.

It is also formed when red hot lead is exposed to the action of air.

PROPERTIES.—A brownish yellow coloured solid, slightly soluble in water, readily soluble in acids and hydrate of potassium. With acids it forms an important series of compounds.

TESTS.—Acid solutions of lead give the following reactions :—

1. A solution of sulphide of hydrogen produces a black precipitate of sulphide of lead, *plumbic sulphide*.
2. A solution of sulphide of ammonium, *ammonic sulphide*, produces a black precipitate of sulphide of lead.
3. Dilute sulphuric acid, *hydric sulphate*, produces a white precipitate of sulphate of lead, *plumbic sulphate*.
4. Hydrochloric acid produces a white precipitate of chloride of lead, *plumbic chloride* ; the precipitate is insoluble in ammonia.
5. A solution of chromate of potassium, *potassic chromate*, produces a yellow precipitate of chromate of lead, *plumbic chromate*.
6. A solution of iodide of potassium, *potassic iodide*, produces a yellow precipitate of iodide of lead, *plumbic iodide*.

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 NITRATE OF LEAD.
*Plumbic Nitrate.*

Symbol,  $\text{Pb}(\text{NO}_3)_2$  ; Equivalent, 381·14.

246. PREPARATION.—Obtained by dissolving lead or its carbonate in hot nitric acid ; the salt is deposited on cooling.

PROPERTIES.—A white crystalline salt, soluble in water, and is employed by dyers and calico printers.

### CARBONATE OF LEAD.

#### *Plumbic Carbonate.*

Symbol,  $\text{PbCO}_3$ ; Equivalent, 267·14.

247. This salt occurs native.

**Manufacture of White Lead.**—This compound is an impure carbonate with hydrate of lead. It is usually prepared by the action of acetic acid vapour and carbonic acid gas upon lead. Sheets of lead are introduced into earthen jars containing a little vinegar (acetic acid), and are arranged side by side in tan or manure, the mouth of each vessel being closed with a board or lid. After the elapse of some months the sheets of lead are taken out of the jars, and the deposit of white lead upon the surface, removed by the mechanical operations of rolling and washing. After being well ground it constitutes commercial white lead. The formation of carbonate of lead may be explained thus:—The vapour of acetic acid attacks the lead, first forming oxide, which soon becomes acetate; lastly, the acetate of lead suffers decomposition, becoming converted into carbonate by the action of the carbonic gas generated from the decomposing tan or manure.

The properties of "white lead" are too generally known to require description. It is largely employed in the manufacture of paint.

### ACETATE OF LEAD.

#### *Plumbic Acetate.*

Symbol,  $\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2 + 3(\text{H}_2\text{O})$ ; Equivalent, 379·14.

248.—This compound is commonly called "sugar of lead."

**PREPARATION.**—Protoxide of lead (litharge) is dissolved in acetic acid, with the assistance of heat. The liquor is run into crystallizing pans; upon cooling, the salt is deposited.

**PROPERTIES.**—A white semi-crystalline solid, soluble in water; the solution possesses a sweet metallic taste; it is a useful reagent. Sugar of lead is extensively used in the preparation of mordants by calico printers and dyers, also for the manufacture of yellow and orange chromates of lead.

## CHROMATE OF LEAD.

*Plumbic Chromate.*

Symbol,  $\text{PbCrO}_4$ ; Equivalent, 324.64.

249. PREPARATION.—A solution of acid chromate of potassium is added to a solution of acetate of lead, and the precipitate of chromate of lead formed is collected on a filter, washed with water, and dried.

PROPERTIES.—A bright yellow compound, insoluble in dilute acids, soluble in a solution of hydrate of potassium. It is largely employed as a paint or pigment, and is commonly known by the name of chrome yellow.

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## BINOXIDE OF LEAD.

*Plumbic Peroxide.*

Symbol,  $\text{PbO}_2$ ; Equivalent, 239.14.

250. PREPARATION.—Red oxide of lead  $2(\text{PbO}) + \text{PbO}_2$ , is treated with dilute nitric acid which dissolves the protoxide, forming a solution of nitrate of lead, and leaving the peroxide as an insoluble powder, to be collected on a filter, washed, and dried.

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## THALLIUM.

Symbol,  $\text{Tl}$ ; Equivalent, 204.

251.—This element was discovered by Mr. Crookes in 1861, in the deposits of a vitriol chamber, in the Hartz Mountains, where iron pyrites are used for the manufacture of sulphuric acid. Thallium was obtained in larger quantities by M. Lamy, who prepared it from the deposit in the lead chamber of M. Kuhlmann, of Lille.

PROPERTIES.—A heavy metal resembling lead in its leading physical properties; in contact with the air it becomes coated with a layer of oxide. Its specific gravity is about that of lead. When strongly heated it inflames, burning with a beautiful green light. It is soluble in acids, and with oxygen it forms two oxides, thallic oxide and thallic acid.

Solutions of thallium give a dark brown precipitate of sulphide of thallium, on the addition of sulphide of ammonium with the assistance of a gentle heat. Sulphide of thallium, *thallic sulphide*, is insoluble in sulphide of ammonium.

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### C O P P E R .

Symbol, Cu ; Equivalent, 63.56.

252. This element is abundantly diffused in nature, being found native as red oxide, sulphide, (copper pyrites), carbonate, (malachite), arsenite, and phosphate. During the year 1864, in the United Kingdom, 214,604 tons of copper ore produced 18,302 tons 13 cwt. of metallic copper.

PREPARATION.—The sulphide is first roasted in a reverberatory furnace, sulphurous acid gas is evolved, the bi-sulphide of iron is converted into oxide, and the sulphide of copper remains unchanged. The roasted ore is then fused with silica (sand) in a furnace ; a “slag” of silicate of iron is formed which separates, and is removed from the surface of the “regulus” of sulphide of copper ; the sulphide of copper is converted into the condition of oxide by further roasting, and lastly the oxide is reduced to the metallic state by the action of carbonaceous matter.

PROPERTIES.—A yellowish red metal, tarnishes slightly when exposed to dry air, in contact with moist air after the elapse of time it becomes coated with a green deposit, which consists principally of carbonate. Dilute hydrochloric or sulphuric acids have scarcely any action upon copper, but it is readily soluble in dilute nitric acid. There are two oxides of copper, suboxide and protoxide ; with acids they form salts, those of the protoxide are ordinarily of a blue or green colour when hydrated ; the salts of the suboxide are usually colourless.

Copper, alloyed with zinc, constitutes brass, and with tin it forms bell metal.

The salts of copper are largely employed by dyers and calico printers.

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### OXIDES OF COPPER.

Suboxide of copper  $\text{Cu}_2\text{O}$ , *Cuprous oxide*.

Protoxide of copper  $\text{CuO}$ , *Cupric oxide*.

## SUBOXIDE OF COPPER.

*Cuprous Oxide.*

Symbol,  $\text{Cu}_2\text{O}$  ; Equivalent, 142.72.

253. PREPARATION.—To a solution of protosulphate of copper, *cupric sulphate*, a solution of tartrate of potassium, *potassic tartrate*, and hydrate of potassium are added until a dark blue solution is formed ; a little grape sugar is added to the liquor, which is then boiled for some minutes, an orange red precipitate of suboxide of copper is formed, and may be collected.

PROPERTIES.—A bright red powder, soluble in acids.

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## SUBCHLORIDE OF COPPER.

*Cuprous Chloride.*

Symbol,  $\text{CuCl}$  ; Equivalent, 98.82.

254. PREPARATION.—This salt is obtained when suboxide of copper is dissolved in hydrochloric acid.

PROPERTIES.—A white salt, slightly soluble in water, readily soluble in hydrochloric acid, *hydric chloride*. A colourless solution of the salt when exposed to the air soon becomes converted into green protochloride of copper.

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## PROTOXIDE OF COPPER.

*Cupric Oxide.*

Symbol,  $\text{CuO}$  ; Equivalent, 79.86.

255. PREPARATION.—When a solution of hydrate of potassium, *potassic hydrate*, is added to a solution of sulphate of copper, *cupric sulphate*, a bluish green precipitate of hydrated oxide is formed ; if, however, the liquor be boiled for a short time, the hydrated oxide is decomposed, and black oxide of copper is precipitated.

PROPERTIES.—A black powder, insoluble in water, soluble in acids. Its anhydrous salts are almost white, whilst the hydrated salts are of a blue or green colour.

TESTS.—Acid solutions of protosalts of copper give the following reactions with the reagents :—

1. A solution of sulphide of hydrogen produces a black precipitate of sulphide of copper, *cupric sulphide*.
2. A solution of sulphide of ammonium produces a similar reaction.
3. A solution of ferrocyanide of potassium produces a mahogany brown precipitate of ferrocyanide of copper.
4. Liquid ammonia first produces a greenish precipitate of basic salt, which changes to hydrate upon a further addition of ammonia, and lastly the hydrate dissolves, forming a dark purple solution.
5. When a piece of clean iron is immersed in an acid solution of copper, a reddish deposit of metallic copper is formed.

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### SULPHATE OF COPPER.

#### *Cupric Sulphate.*

Symbol,  $\text{CuSO}_4, \text{H}_2\text{O} + 4(\text{H}_2\text{O})$ ; Equivalent, 249.86.

256. PREPARATION.—This salt (commonly called “blue vitriol”) is commercially prepared by dissolving copper scales or oxide of copper in dilute sulphuric acid with the aid of heat; the liquor crystallizes upon cooling.

PROPERTIES.—A fine blue crystalline salt, effloresces upon exposure to the air; when heated the crystals lose water of crystallization, becoming of a greenish white colour, and at a higher temperature sulphurous acid gas is given off.

It is a poisonous salt, and is employed in dyeing, calico printing, and medicine, also for exciting galvanic batteries.

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### NITRATE OF COPPER.

#### *Cupric Nitrate.*

Symbol,  $\text{Cu}(\text{NO}_3)_2 + 3(\text{H}_2\text{O})$ ; Equivalent, 241.86.

257. PREPARATION.—Copper or its oxide is dissolved in hot dilute nitric acid, the liquor evaporated, and set aside to crystallize.



PROPERTIES.—A bluish-green salt, deliquesces when exposed to the air. It is used by dyers and calico printers.

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### ACETATE OF COPPER.

#### *Cupric Acetate.*

Symbol,  $\text{Cu}(\text{C}_2\text{H}_3\text{O}_2)_2 + \text{H}_2\text{O}$  ; Equivalent, 199.36.

258. PREPARATION.—This salt is prepared by dissolving one equivalent of carbonate of copper, *cupric carbonate*, in two equivalents of acetic acid, *hydric acetate*, and allowing the solution to crystallize.

PROPERTIES.—A green crystalline salt, readily soluble in water.

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### BASIC ACETATE OF COPPER.

Symbol,  $\text{CuC}_2\text{H}_3\text{O}_2$ .

259.—This compound is commonly called “verdigris.”

PREPARATION.—It is commercially prepared by acting on plates of copper with vinegar or acetic acid. Under the influence of moist air the copper becomes oxidized, combines with the acid, and the salt formed scraped off from time to time.

In France, sheets of copper are stratified with refuse of grapes and allowed to remain for some weeks, acetous fermentation takes place and the copper becomes coated with verdigris.

PROPERTIES.—Bluish-green, or bright blue coloured compound, partially soluble in water, soluble in dilute acids.

The composition of commercial verdigris varies considerably. The blue coloured verdigris is shown by Mr. R. Phillips to be two equivalents of oxide of copper, combined with one equivalent of acetic acid, and six of water ; it is therefore, an hydrated diacetate.

When of a green colour, it consists of a mixture of triacetate and subsesqui-acetate.

Verdigris is employed in medicine, and by dyers, calico printers, &c.

## CHAPTER VI.

OXIDABLE METALS PROPER, WHOSE OXIDES FORM  
WEAK BASES OR ACIDS.

## ANTIMONY.

Symbol, Sb; Equivalent, 122.

260. This element exists as native antimony, also as oxide, sulphide, &c.

PREPARATION.—Antimony is obtained from the native sulphide by heating it with iron filings, when the sulphur unites with the iron, forming sulphide of iron, *ferrous sulphide*, and antimony is set free, and collects at the bottom of the crucible.

PROPERTIES.—A bluish-white brittle metal; upon exposure to the air it undergoes little change. When heated white hot in contact with air, it burns with a white light, evolving white fumes of teroxide of antimony, *antimonic oxide*. There are two oxides, one a feeble base, the other possessing acid properties. Antimony combines with hydrogen, forming antimonide of hydrogen. An alloy of antimony with tin and lead constitutes printers' "type metal." The compounds of antimony are employed in medicine.

## OXIDES OF ANTIMONY.

Teroxide of Antimony	$\text{Sb}_2\text{O}_3$	<i>Antimonic Oxide.</i>
Antimonic Acid	$\text{Sb}_2\text{O}_5$	<i>Antimonic Anhydride.</i>

## TEROXIDE OF ANTIMONY.

*Antimonic Oxide.*Symbol,  $\text{Sb}_2\text{O}_3$ ; Equivalent, 292.

261. This oxide occurs native in Bohemia and Hungary.

PREPARATION.—The oxide is formed when antimony is burned in the air. It may be prepared by adding a solution of hydrate of potassium, *potassic hydrate*, to a solution of terchloride of antimony, *antimonic chloride*; the white precipitate formed is well washed with water to remove all traces of chloride of potassium.

PROPERTIES.—A white powder; at a red heat it fuses, and afterwards volatilizes. It is insoluble in water, soluble in hydrochloric, tartaric, and acetic acids, also in acid tartrate of potassium, *hydropotassic tartrate*, with which it forms tartar emetic. It possesses only weak basic properties, some of its compounds, the (chloride for example), being decomposed by water. The preparations of antimony are highly poisonous.

TESTS :—Acid solutions of antimonic salts give the following reactions :—

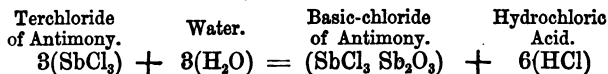
1. A solution of sulphide of hydrogen produces an orange red precipitate of tersulphide of antimony, which is soluble in sulphide of ammonium.
2. With water, concentrated solutions of antimonic chloride, produce a white precipitate of basic chloride of antimony.
3. Ammonia produces a white precipitate of teroxide of antimony, the precipitate is insoluble in excess of the reagent.
4. A solution of chloride of gold, *auric chloride*, produces a precipitate of metallic gold.
5. A solution of oxalic acid, *hydric oxalate*, produces a white precipitate of oxide.

## TERCHLORIDE OF ANTIMONY.

*Antimonic Chloride.*Symbol,  $\text{SbCl}_3$ ; Equivalent, 228.38.

262. PREPARATION.—Powdered antimony or its sulphide is digested in hydrochloric acid, *hydric chloride*; the clear liquor is decanted, and cautiously evaporated.

PROPERTIES.—This compound is soluble in hydrochloric acid, &c., but suffers decomposition when added to water, basic chloride of antimony being formed, thus :—



### TARTRATE OF ANTIMONY AND POTASSIUM.

For the preparation and properties of this salt, refer to potassium salts, par. 101.

### ANTIMONIC ACID.

*Antimonic anhydride.*

Symbol,  $\text{Sb}_2\text{O}_5$ ; Equivalent, 324.

263.—Two hydrated modifications of this acid exist, viz. :— $\text{Sb}_2\text{O}_5, 4(\text{H}_2\text{O})$  and  $\text{Sb}_2\text{O}_5, 5(\text{H}_2\text{O})$ .

Meta-antimonic acid ( $\text{Sb}_2\text{O}_5, 4(\text{H}_2\text{O})$ ) :—This compound is precipitated when a solution of penta chloride of antimony, *antimonic perchloride*, is added to a large quantity of water, or by heating antimoniate of sodium, *sodic antimoniate*, with an excess of hydrate of potassium.

$\text{Sb}_2\text{O}_5, 5(\text{H}_2\text{O})$  is prepared by digesting powdered antimony with nitric acid, *hydric nitrate*.

PROPERTIES. — Hydrated meta-antimonic acid is slightly soluble, in ammonia and water :  $\text{Sb}_2\text{O}_5, 5(\text{H}_2\text{O})$  is insoluble in ammonia and water. Anhydrous antimonic acid is of an orange yellow colour, and is decomposed by heat.

Antimoniate of Potassium is used in the laboratory as a reagent for the detection of sodium salts, with which it produces a white precipitate of antimoniate of sodium.

TESTS.—Hydrochloric acid solutions of antimonic acid or its salts give the following reactions :—

1. A solution of sulphide of hydrogen produces an orange red precipitate of sulphide, soluble in sulphide of ammonium.

2. A solution of chloride of gold produces no reaction.
3. Oxalic acid produces no reaction.

### TIN.

Symbol, Sn ; Equivalent, 118.

264. This element abounds in Cornwall as oxide and sulphide. During the year 1864, 15,211 tons of the ore yielded 10,108 tons of metallic tin.

PREPARATION.—The native oxide is easily reduced to a metallic state by being heated with charcoal.

PROPERTIES.—A yellowish-white metal, tarnishes very slightly when exposed to the air, is soft and readily fusible. With oxygen it forms two oxides, the protoxide (SnO) possessing basic, and the binoxide (SnO<sub>2</sub>) acid, properties. This metal enters into the composition of most of the alloys, from which imitation silver goods (Britannia, Queen's Metal, &c.) are manufactured in Sheffield, Birmingham, &c.

The salts of tin are extensively employed by dyers, colour makers, calico printers, &c.

“Solder” is an alloy of tin with lead.

### OXIDES OF TIN.

Protoxide of Tin SnO *Stannous Oxide.*

Bin oxide of Tin SnO<sub>2</sub> *Stannic Oxide.*

### PROTOXIDE OF TIN.

*Stannous Oxide.*

Symbol, SnO ; Equivalent, 184.

265. This oxide exists native as the mineral tinstone.

PREPARATION.—A solution of hydrate of potassium is added to a solution of protochloride of tin, *stannous chloride*, and the white precipitate of hydrated protoxide washed, dried, and ignited at a dull red heat.

PROPERTIES.—A white solid, soluble in acids, forming crystalline salts.

TESTS.—Acid solutions of stannous salts give the following reactions :—

1. A solution of sulphide of hydrogen produces a dark brown precipitate of sulphide of tin, soluble in sulphide of ammonium.
  2. A solution of carbonate of sodium, *sodic carbonate*, produces a white precipitate of hydrated oxide.
  3. A solution of mercuric chloride produces a white precipitate, which immediately turns grey.
  4. A few drops of a solution of acid chromate of potassium, *potassic dichromate*, produces a green colour.
- 

### PROTOCHLORIDE OF TIN.

*Stannous Chloride.*

Symbol,  $\text{SnCl}_2 + \text{H}_2\text{O}$  ; Equivalent, 206.92.

266. PREPARATION.—Granulated tin is digested with hydrochloric acid, hydrogen gas is evolved, and protochloride of tin formed. The solution yields crystals upon evaporation.

PROPERTIES.—A crystalline salt ; when dissolved in water it is partly decomposed, oxychloride being precipitated. It is largely employed for the preparation of dyes, colours, &c., also as a reagent in the laboratory.

---

### BINOXIDE OF TIN.

*Stannic Oxide.*

Symbol,  $\text{SnO}_2$  ; Equivalent, 150.

267. This compound is often called stannic acid. There are two hydrated modifications of this acid, viz.,  $\text{SnO}_2, \text{H}_2\text{O}$ , and  $\text{SnO}_2, 2(\text{H}_2\text{O})$ .

Hydrated stannic acid,  $\text{SnO}_2, \text{H}_2\text{O}$ , is prepared by adding ammonia to a solution of bichloride of tin.

PROPERTIES.—A white solid, readily soluble in hydrochloric acid. If tartaric acid be added to a solution of bichloride of tin, *stannic chloride*, no precipitate will be formed on the addition of ammonia.

**Hydrated Meta-Stannic Acid**  $[\text{SnO}_2, 2 (\text{H}_2\text{O})]$  is formed by the action of nitric acid upon metallic tin. It is insoluble in cold hydrochloric acid, but soluble when digested for some time; if tartaric acid be added to this solution, a white precipitate of hydrated oxide is formed on the addition of ammonia.

Anhydrous stannic acid ( $\text{SnO}_2$ ) is a white powder, insoluble in nitric acid.

Stannic acid unites with the alkalis forming stannates. Stannate of sodium is used by dyers and calico printers.

**TESTS.**—Acid solutions of stannic salts give the following reactions:—

1. A solution of sulphide of hydrogen produces a yellow precipitate of bi-sulphide of tin, *stannic sulphide*, which is readily soluble in sulphide of ammonium, *ammonic sulphide*.
2. A solution of mercuric chloride produces no precipitate.

## BICHLORIDE OF TIN.

### *Stannic Chloride.*

Symbol,  $\text{SnCl}_4$ ; Equivalent, 259.84.

**268. PREPARATION.**—Granulated tin is dissolved in a mixture of nitric and hydrochloric acids (aqua regia). It may also be prepared by distilling a mixture of finely powdered tin and corrosive sublimate.

**PROPERTIES.**—Anhydrous bichloride of tin is a colourless liquid, and fumes when exposed to the air. It unites with water, solidifying to a crystalline mass. It is extensively employed by dyers and calico printers as a mordant.

## ARSENIC.

Symbol, As; Equivalent, 75.

**269.** This element is found native in a metallic state, and is extensively diffused in combination with other metals, as arsenides of iron, nickel, copper, cobalt, &c.

**PREPARATION.**—Arsenious acid ( $\text{As}_2\text{O}_3$ ) is heated with powdered charcoal, which subtracts the oxygen, reducing the arsenic to the metallic state, which can be separated from the carbon by sublimation.

**PROPERTIES.**—Of a steel grey colour, having a crystalline texture, and very brittle. When exposed to the air it tarnishes and becomes oxidized. If strongly heated in the air it ignites, producing white fumes of oxide. In combination with oxygen it forms two oxides, both of which possess acid properties. With hydrogen it unites, forming arsenide of hydrogen gas. Some of the arsenic compounds are employed as paints, pigments, viz. :—"Orpiment," "Realgar," "Scheele's green," &c. The preparations of arsenic are extremely poisonous.

### OXIDES OF ARSENIC.

Arsenious Acid  $\text{As}_2\text{O}_3$  *Arsenious Anhydride.*

Arsenic Acid  $\text{As}_2\text{O}_5$  *Arsenic Anhydride.*

### ARSENIOUS ACID.

*Arsenious Anhydride.*

Symbol,  $\text{As}_2\text{O}_3$ ; Equivalent, 198.

270. This compound is commonly called white arsenic.

**PREPARATION.**—It is commercially prepared by roasting in a muffled furnace arsenical iron pyrites. The arsenic is oxidized and sublimes, whilst sulphide of iron is left behind. By re-sublimation the crude arsenious acid is rendered sufficiently pure for most practical purposes.

**PROPERTIES.**—A white, almost tasteless powder; when freshly prepared the masses of commercial arsenic are transparent and glassy, but in time become opaque. It is only slightly soluble in cold water (the solution has an acid reaction), readily soluble in acids; when subjected to heat, it volatilizes and is deposited in octahedral crystals; upon cooling it unites with the alkaline bases forming salts called arsenites.



TESTS.—Solutions of arsenious acid give the following reactions :—

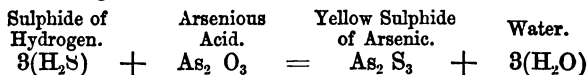
1. A solution of sulphide of hydrogen produces a yellow precipitate of tersulphide of arsenic, *arsenious sulphide*, the precipitate is readily soluble in sulphide of ammonium.
2. A solution of sulphate of magnesium, *magnesian sulphate*, and ammonia produces no precipitate.
3. A solution of ammonio-sulphate of copper produces a bright green precipitate of arsenite of copper.
4. A solution of ammonio-nitrate of silver produces a yellow precipitate of arsenite of silver, *argentic arsenite*.
5. REINSCH'S TEST.—A piece of bright copper introduced into a solution acidulated with hydrochloric acid and heat applied, becomes covered with a steel-grey deposit which consists of an alloy of copper and arsenic.
6. Blowpiped on charcoal produces a smell of garlic.

## 271. SULPHIDES OF ARSENIC.

Bisulphide of Arsenic ...As S ...Red Sulphide (Realgar).

Tersulphide of Arsenic ...As<sub>2</sub> S<sub>3</sub>...Yellow Sulphide (Orpiment).

These sulphides exist native and are employed as pigments. Yellow sulphide is formed when sulphide of hydrogen gas is passed through a solution of arsenious acid, thus :—



## ARSENIC ACID.

*Arsenic Anhydride.*

Symbol, As<sub>2</sub>O<sub>5</sub>; Equivalent, 230.

272. PREPARATION.—Arsenious acid is digested with hot nitric acid until red fumes are no longer evolved; the liquor is then evaporated to dryness.

PROPERTIES.—A white solid ; unites with water, forming hydrated arsenic acid, which may be obtained in crystals. It is a powerful tribasic acid, forming salts, which are isomorphous with the corresponding phosphates. Three arsenates of sodium have been prepared, having a remarkable resemblance to the three tribasic phosphates of sodium.

TESTS.—Solutions of arsenic acid give the following reactions :—

1. A solution of sulphide of hydrogen produces a yellow precipitate of penta-sulphide of arsenic. The formation of this precipitate is accelerated by the aid of heat. The sulphide is soluble in sulphide of ammonium.
2. A solution of nitrate of silver, *argentic nitrate*, produces in neutral solutions a reddish brown precipitate of tribasic arsenate of silver.
3. A solution of sulphate of magnesium and ammonia produces a white crystalline precipitate of arsenate of magnesium and ammonium.

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### TUNGSTEN, OR WOOLFRAM.

Symbol, W ; Equivalent, 184.

273. This element occurs as tungstic acid in combination with iron in the mineral wolfram in Cornwall, also in combination with calcium as tungstate of calcium. Metallic tungsten is obtained by passing a stream of hydrogen gas over tungstic acid heated almost white hot.

It is a white, heavy metal. When heated red hot it ignites, uniting with the oxygen of the air, forming tungstic acid. There are two oxides of tungsten.

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### OXIDES OF TUNGSTEN.

Protoxide of Tungsten  $\text{WO}$ , *Tungstic oxide*.  
Tungstic acid  $\text{WO}_3$ , *Tungstic anhydride*.

274. Protoxide of Tungsten.—When hydrogen is passed over tungstic acid at a moderate red heat, this oxide is formed. No salts of this oxide have been formed with acids.

### TUNGSTIC ACID.

#### *Tungstic Anhydride.*

Symbol,  $\text{WO}_3$ ; Equivalent, 232.

275. PREPARATION.—Native tungstate of calcium, *calcic tungstate*, is treated with hot nitric acid; nitrate of calcium is formed, and tungstic acid is precipitated, and may be collected.

PROPERTIES.—Anhydrous tungstic acid has a yellow colour, insoluble in water and acids. The hydrate possesses a white colour, and combines with the alkalis, forming salts which are soluble in water. The most important salt of tungstic acid is tungstate of sodium, *sodic tungstate*, which has been of late years introduced along with starch for the preparation of non-inflammable fabrics.

TESTS.—Solutions of tungstic acid give the following reactions:—

1. A solution of sulphide of hydrogen produces a brown precipitate of sulphide of tungsten.
2. The solution treated with zinc and hydrochloric acid, is reduced; becoming blue, and then changing to brown.
3. Oxides of tungsten blowpiped in the inner flame with microcosmic salt, produce a blue colour.

### MOLYBDENUM.

Symbol, Mo; Equivalent, 96.

276. This element exists in nature as sulphide and molybdate of lead.

Metallic molybdenum is prepared by strongly heating in a furnace a mixture of molybdic acid and charcoal, in a crucible.

It is a white, almost infusible metal, having a specific gravity of about 8.6.

Three oxides of this metal are known.

## 277. OXIDES OF MOLYBDENUM.

Protoxide of Molybdenum  $\text{MoO}$  *Molybdous Oxide.*

Binoxide of Molybdenum  $\text{MoO}_2$  *Molybdic Oxide.*

Molybdic Acid  $\text{MoO}_3$  *Molybdic Anhydride.*

The salts of the protoxide and binoxide are soluble in water and acids, forming reddish brown solutions. By the action of the air these solutions become of a blue colour.

Molybdic acid is a white powder, insoluble in water, soluble in alkalis and acids. The solution, treated with zinc and hydrochloric acid, is reduced, first becoming blue, then green, and lastly black. It unites with the alkalis, forming molybdates, the most important being molybdate of ammonium, *ammonic molybdate*, which is employed as a reagent for the detection of phosphoric, and arsenic acids.

The oxides of molybdenum when blowpiped in the inner flame with microcosmic salt give a green coloured bead.

## TELLURIUM.

Symbol,  $\text{Te}$ ; Equivalent, 128.

278. This element is found native, also in combination with sulphur, gold, bismuth, and lead.

Tellurium has a remarkable resemblance to selenium, and arsenic in its leading properties. When heated it melts, and if exposed to the air it inflames, burning with a blue flame. It unites with oxygen forming tellurous and telluric acids ( $\text{TeO}_2$  and  $\text{TeO}_3$ ); the former is prepared by dissolving tellurium in nitric acid, and the latter by heating tellurous acid with nitrate of potassium. It unites with hydrogen forming telluride of hydrogen, which resembles sulphide of hydrogen in most of its properties.

Acid solutions containing tellurium give a white precipitate with water, and with sulphide of hydrogen, a black brown precipitate of sulphide of tellurium. When telluric acid is digested with hydrochloric acid, chlorine gas is evolved, and the acid is reduced to the condition of tellurous acid.

## VANADIUM.

Symbol, V ; Equivalent, 68·6.

279. This element occurs in small quantities in iron ores, and in combination with lead as vanadate of lead, *plumbic vanadate*.

It is a white, brittle metal, almost infusible, insoluble in single acids, but dissolves in "aqua regia," forming a dark blue solution.

Three oxides of this metal are known.

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 280. OXIDES OF VANADIUM.

Protoxide of vanadium  $V_2O$  *Vanadous oxide*.

Binoxide of vanadium VO *Vanadic oxide*.

Vanadic acid  $V_2O_5$  *Vanadic anhydride*.

The salts of the binoxide are usually of a blue or green colour. A solution of hydrate of potassium, *potassic hydrate*, gives a greenish-white precipitate, soluble in excess, but insoluble in ammonia.

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 VANADIC ACID.

*Vanadic anhydride*.

Symbol,  $V_2O_5$  ; Equivalent, 185·2.

281.—Vanadic acid is a dark brown solid, insoluble in water, soluble in acids, and with bases it forms red or yellow salts.

Acid solutions containing vanadium do not give any precipitate with sulphide of hydrogen; sulphide of ammonium produces a brown precipitate of sulphide of vanadium which is soluble in excess of the reagent.

Blowpiped in the inner flame with microcosmic salt it gives a brown bead which upon cooling changes to green.

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 TITANIUM.

Symbol, Ti ; Equivalent, 50.

282.—This element occurs as titanitic acid in the minerals rutile, brookite, &c., and in combination with iron as titanitic iron. There are two oxides of titanium.

## 283. OXIDES OF TITANIUM.

Sesquioxide of Titanium  $Ti_2O_3$  *Titanic Oxide.*Titanic Acid  $TiO_2$  *Titanic Anhydride.*

Anhydrous titanic acid is difficultly soluble in concentrated sulphuric acid.

Blowpiped in the inner flame with microcosmic salt it gives a violet coloured bead, which becomes colourless when blowpiped in the oxidation flame.

When solutions of titanic acid are treated with hydrochloric acid and metallic zinc, the titanic acid is reduced to the condition of titanic oxide, the solution first becoming of a blue colour, and then changing to violet.

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NIOBIUM.

Symbol, Nb; Equivalent, 47.

284 This element occurs in the mineral tantalite, in Bavaria. The metal is obtained by reducing the double fluoride of niobium and potassium with potassium. It is insoluble in nitric acid, *hydric nitrate*; with oxygen it forms niobous, and niobic acids ( $NbO$  and  $NbO_2$ ).

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TANTALUM (Columbium).

Symbol, Ta; Equivalent, 187.6.

285. This rare element occurs in tantalite and other minerals in Sweden, &c.

It is prepared by decomposing fluoride of tantalum and potassium, with potassium.

A grey metal, almost insoluble in acids; with oxygen it forms tantalic oxide and tantalic acid.

## CHAPTER VII.

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**METALS WHOSE OXIDES ARE REDUCED BY HEAT.**  
**SILVER.**

Symbol, Ag ; Equivalent, 107·97.

286. This element occurs as sulphide in argentiferous galena, also as chloride, &c.

PREPARATION.—The ore is first roasted to expel sulphur, then reduced to the metallic state ; and submitted to the process of cupellation, which consists in exposing the alloy to the oxidizing action of air in a reverberatory furnace ; the lead is rapidly converted into oxide, leaving metallic silver.

PROPERTIES.—A brilliant white metal, unalterable in dry air, with oxygen it forms an oxide, and is soluble in nitric acid, *hydric nitrate*. When alloyed with copper, in the proportion of 18 of copper to 222 of silver, it constitutes “standard silver.” The salts of silver are largely used in photography, and for electro-plating metals.

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**PROTOXIDE OF SILVER.***Argentio Oxide.*

Symbol,  $\text{Ag}_2\text{O}$  ; Equivalent, 231·94.

287. PREPARATION.—If a solution of hydrate of potassium, *potassic hydrate*, is added to a solution of nitrate or sulphate of silver, *argentio nitrate or sulphate*, a precipitate of oxide of silver is formed, which may be collected, well washed with water, to remove the nitrate or sulphate of potassium formed, and dried.

PROPERTIES.—A dark brown powder, soluble in acids, with which it unites, forming crystalline salts.

TESTS.—Acid solutions of silver salts, giving the following reactions :—

1. A solution of sulphide of hydrogen produces a black precipitate of sulphide of silver, *argentic sulphide*.
2. A solution of sulphide of ammonium produces a black precipitate of sulphide of silver.
3. Hydrochloric acid produces a white precipitate of chloride of silver, *argentic chloride*; the precipitate is soluble in ammonia.
4. A solution of chromate of potassium, *potassic chromate*, produces a maroon red precipitate of chromate of silver, *argentic chromate*.

---

### NITRATE OF SILVER.

#### *Argentic Nitrate.*

Symbol,  $\text{AgNO}_3$ ; Equivalent, 169.97.

288. PREPARATION.—This important compound is formed when metallic silver or its oxide is dissolved in nitric acid, with the aid of heat, and the solution set aside to crystallize.

PROPERTIES.—A heavy crystalline salt, extremely soluble in water. A solution of this salt is extensively employed in photography, also as a reagent for the detection and quantitative estimation of chlorine in chlorides. Fused nitrate of silver is used in medicine, and is called "lunar caustic."

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### CHLORIDE OF SILVER.

#### *Argentic Chloride.*

Symbol,  $\text{AgCl}$ ; Equivalent, 143.48.

289. PREPARATION.—Chloride of sodium, *sodic chloride*, is added to a solution of nitrate of silver, *argentic nitrate*; nitrate of sodium, *sodic nitrate*, and a precipitate of chloride of silver are formed.



**PROPERTIES.**—A white solid, insoluble in acids, but soluble in ammonia. When moistened with water and exposed to the action of light, it gradually assumes a dark colour.

### MERCURY.

Symbol, Hg; Equivalent, 200.

290. This element occurs native in the metallic state; also as persulphide (cinnabar).

**PREPARATION.**—It is principally obtained from the sulphide by distillation with iron filings or lime (oxide of calcium); sulphide of iron or calcium is formed, and the metal distils over, and is condensed.

**PROPERTIES.**—Mercury is remarkable among metals for existing as a fluid at ordinary temperatures; it possesses a silvery lustre, and is readily soluble in nitric acid, but difficultly soluble in sulphuric acid, *hydric sulphate*. Unites with oxygen forming two oxides, and with the acids it forms salts. Mercury possesses the peculiar property of dissolving most metals forming “amalgams.” It is largely employed in the preparation of medicinal compounds, also for the manufacture of thermometers, barometers, &c., and in conjunction with tin it forms an amalgam which is used for silvering mirrors, reflectors, &c.

### OXIDES OF MERCURY.

Suboxide of mercury  $\text{Hg}_2\text{O}$  *Mercurous oxide*.

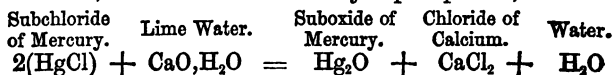
Protoxide of mercury  $\text{HgO}$  *Mercuric oxide*.

### SUBOXIDE OF MERCURY.

*Mercurous Oxide.*

Symbol,  $\text{Hg}_2\text{O}$ ; Equivalent, 416.

291. **PREPARATION.**—When subchloride of mercury, *mercurous chloride*, is digested with an excess of lime water, chloride of calcium, *calcic chloride*, is formed and remains in solution, and suboxide of mercury is precipitated, thus:—



PROPERTIES.—A dark grey heavy powder, decomposed by heat, being resolved into metallic mercury and protoxide of mercury, *mercuric oxide*. It is soluble in most acids, with which it forms mercurous salts.

TESTS.—Acid solutions of mercurous salts give the following reactions :—

1. A solution of sulphide of hydrogen produces a black precipitate of mercurous sulphide.
2. A solution of sulphide of ammonium produces a black precipitate of mercurous sulphide.
3. Hydrochloric acid produces a white precipitate of subchloride of mercury, *mercurous chloride*; this precipitate is turned black by the addition of ammonia.
4. A solution of iodide of potassium, *potassic iodide*, produces a greenish yellow precipitate of subiodide of mercury, *mercurous iodide*.

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#### SUBNITRATE OF MERCURY.

##### *Mercurous Nitrate.*

Symbol,  $\text{HgNO}_3$ ; Equivalent, 262.

292. PREPARATION.—When mercury is acted upon by hot nitric acid, a solution of subnitrate of mercury is formed providing that the mercury is in excess of the acid; the liquor deposits crystals upon cooling.

PROPERTIES.—A crystalline salt, soluble in water.

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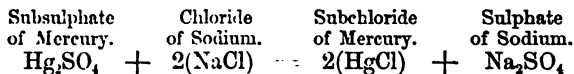
#### SUBCHLORIDE OF MERCURY.

##### *Mercurous Chloride.*

Symbol,  $\text{HgCl}$ ; Equivalent, 235.46.

293. This compound is commonly called “calomel.”

**PREPARATION.**—When a mixture of subsulphate of mercury and chloride of sodium is heated, sulphate of sodium and subchloride of mercury are formed, thus:—



The subchloride of mercury is sublimed, and may be collected and well washed with water to remove any traces of the protochloride (corrosive sublimate) with which it may be contaminated.

**PROPERTIES.**—A white powder; solutions of the alkalis (hydrate of potassium, &c.) immediately renders it black, suboxide of mercury being formed. It is extensively used in medicine.

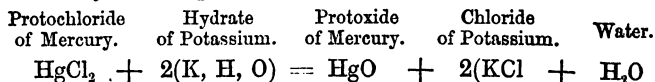
## PROTOXIDE OF MERCURY.

### *Mercuric Oxide.*

Symbol,  $\text{HgO}$ ; Equivalent, 216.

**294. PREPARATION.**—Method I.—When mercury is heated in contact with air for some hours, at a temperature of about 600 degrees Fahrenheit, it undergoes oxidation, and becomes converted into red scales of protoxide.

Method II.—A solution of hydrate of potassium is added to a hot solution of protochloride of mercury, *mercuric chloride*, the precipitate is collected on a filter, and dried. The reaction of the hydrate of potassium may be expressed thus:—



**PROPERTIES.**—An orange-yellow, or brick-red powder; when heated red hot oxygen gas is set free, the mercury becoming sublimed. It is readily dissolved by acids, forming salts.

**TESTS.**—Acid solutions of mercuric salts give the following reactions:—

1. A solution of sulphide of hydrogen produces a black brown precipitate of protosulphide of mercury, *mercuric sulphide*.

2. A solution of sulphide of ammonium produces a similar reaction to that of sulphide of hydrogen.
3. A solution of iodide of potassium produces a scarlet precipitate of proto-iodide of mercury, *mercuric iodide*.
4. Hydrochloric acid produces *no* precipitate.

### PROTONITRATE OF MERCURY.

#### *Mercuric Nitrate.*

Symbol,  $\text{Hg}(\text{NO}_3)_2$ ; Equivalent, 324.

295. PREPARATION.—Mercury is dissolved in excess of hot nitric acid and a portion of the solution tested for subnitrate with hydrochloric acid; if a precipitate is formed, more nitric acid must be added to convert the whole of the mercurous into mercuric nitrate. The salt is deposited upon cooling.

PROPERTIES.—A colourless crystalline salt, readily soluble in water.

### PROTOSULPHATE OF MERCURY.

#### *Mercuric Sulphate.*

296. Symbol,  $\text{HgSO}_4$ ; Equivalent, 296.

PREPARATION.—When one equivalent of mercury is heated with two equivalents of sulphuric acid, one equivalent of sulphurous acid gas is given off, and one equivalent of protosulphate of mercury is formed, thus:—

Mercury.	Sulphuric Acid.	Protosulphate of Mercury.	Water.	Sulphurous Acid.
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PROPERTIES.—A crystalline salt, soluble in water. It is employed in the preparation of sub-sulphate of mercury, *mercurous sulphate*. This compound is formed when one equivalent of mercury is triturated with one equivalent of potosulphate, thus:—

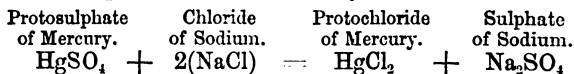
Protosulphate of Mercury.	Mercury.	Subsulphate of Mercury.
$\text{HgSO}_4$	+ Hg =	$\text{Hg}_2\text{SO}_4$

## PROTOCHLORIDE OF MERCURY.

*Mercuric Chloride.*Symbol,  $\text{HgCl}_2$ ; Equivalent, 270.92.

297. This compound is commonly called "corrosive sublimate."

PREPARATION.—Protosulphate of mercury is heated with chloride of sodium, *sodic chloride*; sulphate of sodium, *sodic sulphate*, and protochloride of mercury are formed:—



PROPERTIES.—A heavy crystalline salt, soluble in water, alcohol, and ether. It is a powerful poison, and is employed in medicine.

## PROTOIODIDE OF MERCURY.

*Mercuric Iodide.*Symbol,  $\text{HgI}_2$ ; Equivalent, 453.76.

298. PREPARATION.—A solution of iodide of potassium, *potassic iodide*, is added to a solution of mercuric chloride (in slight excess), and the precipitate collected, washed, and cautiously dried.

PROPERTIES.—A beautiful scarlet-coloured powder, insoluble in water. When heated it becomes yellow, and upon cooling red. It is soluble in iodide of potassium, or mercuric chloride, and is employed in medicine.

## BISULPHIDE OF MERCURY.

*Mercuric Persulphide.*Symbol,  $\text{HgS}_2$ ; Equivalent, 264.

299. This compound exists native in the mineral cinnabar, and is commonly called "vermilion."

PREPARATION.—Sulphur and mercury are heated together; the vessel is closely covered with a lid to prevent the mass taking fire; a black sulphide of mercury is formed. By sublimation it is converted into the dark red crystalline persulphide.

PROPERTIES.—When in the powdered state it is of a brilliant red colour, insoluble in water and dilute acids, and is largely employed as a paint or pigment.

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G O L D .

Symbol, Au ; Equivalent, 196·67.

300. This element is found native in Australia and California, also in Wales. During the year 1864, five mines in Merionethshire yielding auriferous quartz produced 2,887 ounces of this valuable metal.

PROPERTIES.—A yellow ductile and malleable metal. It is one of the heaviest of metals, having a specific gravity of 19·5. It is unchanged by exposure to air, insoluble in all single acids, but is soluble in nitro-hydrochloric acid (aqua regia), terchloride of gold being formed. The uses and applications of gold are too-well known to require description. With oxygen it forms two oxides.

---

OXIDES OF GOLD.

Protoxide of Gold  $\text{Au}_2\text{O}$  *Aurous Oxide*.

Teroxide of Gold  $\text{Au}_2\text{O}_3$  *Auric Oxide*.

---

PROTOXIDE OF GOLD.

*Aurous Oxide*.

Symbol,  $\text{Au}_2\text{O}$  ; Equivalent, 409·84.

301. If a solution of hydrate of potassium, *potassic hydrate*, is added to a solution of protochloride of gold, *aurous chloride*, a greenish coloured precipitate of protoxide of gold is formed.

---

PROTOCHLORIDE OF GOLD.

*Aurous Chloride*.

Symbol,  $\text{AuCl}$  ; Equivalent, 232·13.

303. PREPARATION.—Terchloride of gold, *auric chloride*, is exposed to a temperature of about 400°F., chlorine gas is liberated, and a yellowish white solid of protochloride of gold is formed. It is used for the preparation of protoxide of gold.

## TEROXIDE OF GOLD.

*Auric Oxide.*

Symbol,  $\text{Au}_2\text{O}_3$ ; Equivalent, 441.84.

303.—PREPARATION.—To a solution of terchloride of gold, oxide of magnesium, *magnesium oxide*, is added; a precipitate of aurate of magnesium, *magnesium aurate*, is formed, which is first well washed with water, and then treated with dilute nitric acid, *hydric nitrate*; nitrate of magnesium, *magnesium nitrate*, is formed, and auric oxide is left as an insoluble powder.

PROPERTIES.—Auric oxide is of a reddish brown colour, soluble in hydrochloric and strong nitric acids.

TESTS.—Acid solutions of gold give the following reactions:

1. A solution of sulphide of hydrogen produces a black precipitate of sulphide of gold, *auric sulphide*, which is soluble in sulphide of ammonium.
2. A solution of protochloride of tin, *stannous chloride*, produces a dark purple colour (purple of cassius).
- 3.—A solution of protosulphate of iron, *ferrous sulphate*, produces a precipitate of gold. The solution is brown by reflected light, and blue by transmitted light.

## TERCHLORIDE OF GOLD.

*Auric Chloride.*

Symbol,  $\text{AuCl}_3$ ; Equivalent, 303.05.

304. PREPARATION.—Gold is dissolved in a mixture of nitric and hydrochloric acids; the liquor upon evaporation deposits the salt.

PROPERTIES.—This is the most important compound of gold. It is a yellow crystalline salt, extremely soluble in water, and is employed in medicine and photography.

## PLATINUM.

Symbol, Pt; Equivalent, 197.88.

305. This element is found native alloyed with numerous other metals.

PROPERTIES.—A white metal, malleable and ductile, possesses great weight, having a specific gravity of 21. It is infusible, excepting by the heat of the oxy-hydrogen flame and electrical current. It is not affected by exposure to the air. It is insoluble in single acids, but is soluble in nitro-hydrochloric acid, forming bichloride. Platinum is manufactured into wire, foil, crucibles, retorts, &c. for chemical purposes. It unites with oxygen, forming two oxides, both of which are reduced to the metallic state by ignition.

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### OXIDES OF PLATINUM.

Protoxide of Platinum  $\text{PtO}$  *Platinous Oxide*.

Binoxide of Platinum  $\text{PtO}_2$  *Platinic Oxide*.

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### PROTOXIDE OF PLATINUM.

*Platinous Oxide*.

Symbol,  $\text{PtO}$ ; Equivalent, 213·88.

306. A solution of protochloride of platinum, *platinous chloride*, is digested with a solution of hydrate of potassium; the black precipitate of protoxide of platinum is collected on a filter, washed, and dried. It is readily soluble in acids; the solution does not form a precipitate with chloride of ammonium, *ammonic chloride*.

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307. Protochloride of Platinum ( $\text{PtCl}_2$ ).—When bichloride of platinum is exposed for some time to a heat of about 400 degrees Fahr., chlorine gas is evolved, and this salt is formed.

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### BINOXIDE OF PLATINUM.

*Platinic Oxide*.

Symbol,  $\text{PtO}_2$ ; Equivalent, 229·88.

308. A solution of binitrate of platinum, *platinic nitrate*, is added to a solution of hydrate of potassium; the precipitate of binoxide of platinum is collected on a filter, washed, and dried. It unites with acids forming orange yellow salts.



TESTS.—Acid solutions of platinum give the following reactions :—

1. A solution of sulphide of hydrogen produces a black precipitate of sulphide of platinum, *platinic sulphide*, which is soluble in sulphide of ammonium.
2. A solution of chloride of ammonium or potassium produces a yellow crystalline precipitate of chloride of platinum and ammonium or chloride of platinum and potassium.

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## BICHLORIDE OF PLATINUM.

### *Platinic Chloride.*

Symbol,  $\text{PtCl}_4$  ; Equivalent, 389.72.

309. PREPARATION.—Platinum is digested with a mixture of nitric and hydrochloric acids ; the solution is evaporated to a syrup which upon cooling crystallizes.

PROPERTIES.—A dark brown crystalline salt, soluble in water and alcohol. A solution of this compound is employed in the laboratory for the quantitative estimation of potassium, ammonium, and organic bases. When heated it is decomposed, chlorine being evolved and protochloride of platinum formed.

---

## IRIDIUM.

Symbol,  $\text{Ir}$  ; Equivalent, 198.

310. This element occurs in platinum ores associated with osmium.

The metal is insoluble in acids. When heated with a mixture of nitrate, hydrate, and chlorate of potassium, it is converted into sesquioxide, which is soluble in nitro-hydrochloric acid, forming a dark red solution of bichloride of iridium ( $\text{IrCl}_4$ ).

Bichloride of iridium gives a deep red precipitate with chloride of ammonium, *ammonic chloride*, and with nitrate of silver, *argentic nitrate*, a blue precipitate which changes white after the elapse of time.

There are four oxides of iridium, which are devoid of any commercial interest.

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### RUTHENIUM.

Symbol, Ru; Equivalent, 104.4.

311. This rare element occurs in platinum ores, associated with numerous other metals.

It resembles iridium, and is insoluble in aqua regia. The metal is brittle and almost infusible; when heated in the air, it oxidizes; with oxygen it forms proto and sesquioxide ( $\text{RuO}$  and  $\text{Ru}_2\text{O}_3$ ). It possesses a specific gravity of about 8.6.

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### NORIUM.

Symbol, No.

312. This element according to Svanberg is supposed to exist in certain varieties of zircon.

Its properties have not yet been described.

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### RHODIUM.

Symbol, R; Equivalent, 104.4.

313. This element occurs in small proportions in platinum ores.

It is insoluble in acids, dissolves, however, after being strongly heated with acid sulphate of potassium, *hydropotassic sulphate*. Solutions of rhodium are usually rose coloured.

With a solution of sulphide of hydrogen it gives a brown precipitate of sulphide of rhodium, *rhodic sulphide*, which is insoluble in sulphide of ammonium.

Rhodium unites with oxygen forming protoxide ( $\text{RO}$ ) and sesquioxide ( $\text{R}_2\text{O}_3$ ). The metal possesses a specific gravity approaching that of lead.

---

### PALLADIUM.

Symbol, Pd; Equivalent, 106.6.

314. This metal occurs in platinum ores and Brazilian gold dust. It is soluble in nitric acid.

Solutions of palladium give a dark brown precipitate with sulphide of hydrogen, of sulphide of palladium, and with iodide of potassium, a black precipitate of iodide of palladium, *palladic iodide*. A solution of chloride of ammonium, *ammonic chloride*, does not produce a precipitate with palladium salts; this reaction is applied to the separation of platinum from palladium.

The metal possesses a specific gravity of about 11.8; with oxygen it unites, forming two oxides, proto (PdO) and bin-oxide (PdO<sub>2</sub>).

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### OSMIUM.

Symbol, Os; Equivalent, 199.2.

315. This metal exists in combination with iridium in platinum ores. With oxygen it forms five oxides, viz., protoxide, sesquioxide, binoxide, osmous, and osmic acids.

Osmous acid (OsO<sub>3</sub>) is not known in the free state, but only in combination with bases.

Osmic acid (OsO<sub>5</sub>) is a crystalline compound, and when heated it evolves pungent, irritating fumes having a smell resembling chlorine. Solutions of osmic acid stain the skin black, and by the reducing action of sulphurous or formic acids a precipitate of metallic osmium is produced. Sulphide of hydrogen gives a blackish-brown precipitate of sulphide of osmium, which is insoluble in sulphide of ammonium.

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## APPENDIX.

316.—Table of Specific Gravities of the most important  
Metals and the Non-gaseous Metalloids.

NAME.	SPECIFIC GRAVITY. $\text{WATER} = 1.$
Aluminium .....	2.60
Antimony .....	6.80
Arsenic .....	5.80
Bismuth .....	9.90
Cadmium .....	8.70
Cobalt .....	8.50
Copper .....	8.96
Gold .....	19.50
Iron .....	7.80
Lead .....	11.45
Magnesium .....	1.75
Manganese .....	8.00
Mercury .....	13.59
Nickel .....	8.80
Palladium .....	11.80
Platinum .....	21.50
Potassium .....	0.865
Silver .....	10.50
Sodium .....	0.972
Strontium .....	2.54
Tin .....	7.30
Tungsten .....	17.40
Zinc .....	7.00
Boron .....	2.68
Bromine .....	2.97
Iodine .....	4.94
Phosphorus .....	1.77
Selenium .....	4.80
Silicium .....	2.49
Sulphur .....	1.98

317.—Table of the Specific Gravities of Gases and Vapours.

NAME.	SPECIFIC GRAVITY. AIR = 1·000.
Ammonia Gas.....	0·589
Arsenic Vapour .....	10·420
Bromine Vapour .....	5·539
Bin oxide of Nitrogen.....	1·039
Carbon Vapour .....	0·418
Carbonic Acid .....	1·524
Carbonic Oxide .....	0·973
Chlorine .....	2·470
Cyanogen .....	1·811
Hydrogen .....	0·0693
Heavy Carbide of Hydrogen..	0·969
Hydrochloric Acid Gas .....	1·269
Iodine Vapour .....	8·716
Light Carbide of Hydrogen...	0·554
Mercury Vapour .....	7·000
Nitrogen .....	0·969
Nitrous Oxide.....	1·525
Oxygen .....	1·106
Phosphorus Vapour .....	4·350
Phosphide of Hydrogen ....	1·240
Sulphur Vapour.....	2·200
Sulphide of Hydrogen .....	1·177
Sulphurous Acid .....	2·210
Water Vapour .....	0·625

318. Process of determining the Specific Gravity of Solids  
heavier than water.

---

1st. Weigh the solid in air.

2nd. Weigh the solid when immersed in water.

3rd. Subtract the weight of the solid in water from its weight  
in air. This will give the weight of water displaced.

4th. Divide the weight of the solid in air by its loss in weight  
when immersed in water. The quotient will give the  
specific gravity of the solid as compared to water as a  
standard.

EXAMPLE :—

Supposing the weight of the solid in air = 420 grains  
and “ “ water = 345 “  
then the weight lost by immersion is 75 grains. The follow-  
ing statement will give the specific gravity :—

As  $75 : 420 :: 1 : x = 5.6$ , the specific gravity of the solid.

NOTE.—If the solid whose specific gravity is to be deter-  
mined, is soluble in water, some other liquid of known gravity  
(density) must be used in which it is insoluble. Oil of  
turpentine, olive oil, alcohol, &c., may be employed.

### 319. Process of determining the Specific Gravity of Solids which are lighter than water.

---

When the solid, whose density is required, is lighter than water, it must be attached to a piece of a heavy solid of sufficient weight, that both when together shall sink in water.

Determine experimentally—

- 1st. The weight of the light solid in air.
- 2nd.    "       "    heavy   "    air.
- 3rd.    "       "       "       "    water.
- 4th.    "       "       "    two together in water.

From the difference of the weight of the two in water, and their weight in air, subtract the difference between the weight of the heavy solid in air, and its weight in water, the remainder is the weight of a quantity of water equal to the light solid, from which the specific gravity of the substance may be obtained by simple proportion.

EXAMPLE :—

- 1st. The weight of the light solid in air 12 grains.
- 2nd.    "       "    heavy   "    22   "
- 3rd.    "       "       "       "    water 19   "
- 4th.    "       "       "    both together in water 8   "

From the weight of both in air ..... 34 grains.

Deduct the weight of both in water ..... 8   "

—  
26 grains.

And from the remainder deduct (22 — 19) ..... 3   "

—  
Weight of water displaced by light body alone = 23 grains.

Then :—

As 23 : 12 :: 1 : x = 0.5217 = The specific gravity of the light solid.



## 320. Process of determining the Specific Gravities of Gases.

---

The specific gravity of gases are commonly referred to air as a standard, 1 or 1000. One hundred cubic inches of pure dry air, according to Dr. Prout, weigh 31·0117 grains at a temperature of 60 degrees Fahr., and barometrical pressure of 30 inches. A small glass flask furnished with a stopcock is weighed full of air, the temperature and pressure being noted at the time. It is then exhausted of its air by the action of an air pump, and weighed in the vacuous state; the weight of air withdrawn by exhaustion is thus determined. The flask is then carefully connected with a jar containing the gas, the specific gravity of which is to be ascertained. The stopcocks are opened, and a quantity of gas passes from the jar into the flask; the temperature of the air and barometrical pressure must be noted. The stopcocks being closed, the flask is weighed; the difference between the weight of the flask when containing the gas under examination, and when in the vacuous state, is the weight of a bulk of gas equal to the bulk of air whose place it occupied. The weight of air having already been determined, the specific gravity from these data may be easily calculated. If any alteration in the temperature and pressure have occurred during the operation, a correction will be required to be made according to the rule described at par. 321.

- **EXAMPLE.**—Suppose the flask to weigh 1015·49 grains with air, and to lose 15·49 grains of air by exhaustion, and to weigh 1028·67 grains when filled with carbonic acid; then as the air is taken as a standard 1, we have the following proportion :—

$$\text{As } 15\cdot49 : 28\cdot67 :: 1 : x = 1\cdot52$$

1·52 = Specific gravity of carbonic acid gas, as compared with air.

### 321. Rules for Correcting the Volume of a Gas when change of temperature and pressure occur.

---

Rule for change in bulk by pressure.

The volume which a gas should possess at one pressure may be calculated from its known volume at another pressure by the following proportion :—As the pressure to which the gas has to be corrected, is to the observed pressure, so is the observed volume, to the volume required.

EXAMPLE.—Let the pressure to which the gas is to be reduced be the normal pressure of 30 inches, the observed pressure 29·5 inches, and the volume 22·4 measures; then as 30 : 29·5 :: 22·4 : x = 22·026 = the volume of gas at 30 inches pressure.

Rule for change in bulk by temperature.

Gases expand by heat  $\frac{1}{460}$ th of their bulk for each degree Fahrenheit rise in temperature; they also contract in volume in the same ratio. The expansion and contraction is uniform for all degrees of heat, hence the volume of a gas at 0 degrees Fahrenheit being 460, will measure 461 volumes at 1 degree Fahrenheit.

EXAMPLE.—Let the observed temperature be 70 degrees Fahrenheit, the volume 22·4 measures, and the required temperature 60 degrees Fahrenheit, then 60 from 70 = 10 degrees rise in temperature; this is equal to  $\frac{1}{460} \times 10 = \frac{10}{460}$

$$22\cdot4 \div \frac{1}{46} = \cdot48$$

$$22\cdot4 - \cdot48 = 21\cdot92 = \left\{ \begin{array}{l} \text{volume of the gas at 60} \\ \text{degrees Fahrenheit.} \end{array} \right.$$

NOTE.—It is necessary in all cases to reduce the volume of a gas for change in temperature before correcting for alteration in volume by pressure.

---

## 322. CONDENSATION BY VOLUME.

When gases enter chemical combination, the volume often suffers diminution in bulk arising from condensation.

The following examples will render this reaction intelligible to the student :—

## WATER VAPOUR.

Ex. 1.—When a mixture of two volumes of hydrogen gas and one volume of oxygen gas are exploded by an electric spark, they enter into combination and condense to two volumes of water vapour.

## AMMONIA GAS.

Ex. 2.—When a mixture of three volumes of hydrogen gas and one volume of nitrogen are caused to unite by an electric discharge, the four volumes of gases are condensed to two volumes of ammonia gas.

## SULPHIDE OF HYDROGEN.

Ex. 3.—Two volumes of hydrogen enter into combination with one volume of sulphur and condense to two volumes of sulphide of hydrogen gas.

Combination of gaseous elements takes place in many cases without alteration or condensation of volume.

EXAMPLE:—Hydrogen unites with chlorine, bromine, iodine, &c., forming hydrochloric, hydrobromic, hydriodic acid gases, &c., without condensation.

323. Rule by which the Specific Gravity of a Compound Gas, as compared with Hydrogen as a standard, may be calculated.

Add up the molecular equivalents of the compound, then divide this number by the number of molecular volumes which the gas measures after combination. This will give the specific gravity of one volume of the compound as compared with hydrogen taken as 1.000.

EXAMPLES :—

1. Water Vapour ( $H_2O$ ).

$$\begin{array}{rclcl} H & = & 1 \times 2 & = & 2 = 2 \text{ vols.} \\ O & = & 16 & = & 16 = 1 \text{ "} \\ \hline & & & & 18 \quad 3 \text{ vols. condense to 2 vols.} \\ \hline \end{array}$$

$$18 \div 2 = 9 = \text{specific gravity of 1 vol.}$$

2. Sulphide of Hydrogen ( $H_2S$ ).

$$\begin{array}{rclcl} H & = & 1 \times 2 & = & 2 = 2 \text{ vols.} \\ S & = & 32 & = & 32 = 1 \text{ "} \\ \hline & & & & 34 \quad 3 \text{ vols. condense to 2 vols.} \\ \hline \end{array}$$

$$34 \div 2 = 17 = \text{specific gravity of 1 vol.}$$

3. Ammonia ( $NH_3$ ).

$$\begin{array}{rclcl} N & = & 14 & = & 14 = 1 \text{ vol.} \\ H & = & 1 \times 3 & = & 3 = 3 \text{ "} \\ \hline & & & & 17 \quad 4 \text{ vols. condense to 2 vols.} \\ \hline \end{array}$$

$$17 \div 2 = 8.5 = \text{specific gravity of 1 vol.}$$

4. Hydrochloric Acid ( $HCl$ ).

$$\begin{array}{rcl} H & = & 1 = 1 \text{ vol.} \\ Cl & = & 35.46 = 1 \text{ "} \end{array}$$

$$\hline 36.46 \quad 2 \text{ vols. (condensation of volume does not occur.)}$$

$$36.46 \div 2 = 18.23 = \text{specific gravity of 1 vol.}$$

324. Rule by which the per-centage composition by volume of a compound gas or liquid may be calculated according to the "new" notation.

Hydrogen, nitrogen, chlorine, bromine, iodine, mercury, oxygen, sulphur, fluorine, &c., possess the atomic volume 1 or 2 molecular volumes. Phosphorus and arsenic have only the atomic volume of  $\frac{1}{2}$  and molecular volume 1.

1st. Add up the molecular volumes of the compound, the percentage composition of which is to be determined.

2nd. State by simple proportion, as the sum total of the molecular volumes of the compound is to 100, so is the molecular volume of the element in the compound the per-centage of which is to be determined, to x.

X = the per centage of the element in the compound.

3rd. Repeat No. 2 statement for each element in the compound.

Supposing nitric acid ( $\text{HNO}_3$ ) be taken as an example.

$$\begin{array}{rcl} \text{Nitric Acid} \left\{ \begin{array}{l} \text{H} = 2 \\ \text{N} = 2 \\ \text{O}_3 = 2 \times 3 \end{array} \right. & = & \begin{array}{l} 2 \\ 2 \\ 6 \end{array} \\ & & \hline & & 10 \\ & & \hline \end{array}$$

$$\text{As } 10 : 100 :: 2 : x = 20 \quad \text{Hydrogen.}$$

$$\text{As } 10 : 100 :: 2 : x = 20 \quad \text{Nitrogen.}$$

$$\text{As } 10 : 100 :: 6 : x = 60 \quad \text{Oxygen.}$$

#### RESULTS.

$$\text{Hydrogen} = 20$$

$$\text{Nitrogen} = 20$$

$$\text{Oxygen} = 60$$

$$\hline 100$$

325. Rule by which the per-centage composition by volume of a compound gas or liquid may be calculated according to the "old" notation.

One equivalent of hydrogen, nitrogen, chlorine, bromine, iodine, fluorine, &c., occupy two volumes, and one equivalent of oxygen, sulphur, arsenic, phosphorus, &c., have a capacity of one volume.

1st. Add up the volumes of the compound, the percentage composition of which is to be determined.

2nd. State by simple proportion, as the sum total of the volumes of the compound is to 100, so is the volume of the element in the compound, the percentage of which is to be determined, to x.

X = the per centage of the element in the compound.

3rd. Repeat No. 2 statement for each element in the compound.

Supposing nitric acid ( $\text{HNO}_3$ ) be taken as an example.

$$\begin{array}{rcl} \text{Nitric Acid} \left\{ \begin{array}{l} \text{H} = 2 \\ \text{N} = 2 \\ \text{O}_3 = 1 \times 6 \end{array} \right. & = & \begin{array}{l} 2 \\ 2 \\ 6 \end{array} \\ & & \hline & & 10 \\ & & \hline \end{array}$$

$$\text{As } 10 : 100 :: 2 : x = 20 = \text{Hydrogen.}$$

$$\text{As } 10 : 100 :: 2 : x = 20 = \text{Nitrogen.}$$

$$\text{As } 10 : 100 :: 6 : x = 60 = \text{Oxygen.}$$

#### RESULTS.

$$\text{Hydrogen} = 20$$

$$\text{Nitrogen} = 20$$

$$\text{Oxygen} = 60$$

$$\hline 100 \\ \hline$$

326. Rule by which the per-centage by weight of each element in a salt, &c., may be calculated.

1st. Add up the equivalents of the elements in the compound, the per centage composition of which is to be determined.

2nd. State by simple proportion, as the equivalent of the compound is to 100, so is the quantity of the element in the compound the per centage of which is to be found, to x.

X = the per centage of the element in the compound.

3rd. Repeat No. 2 statement for each element in the compound.

Supposing sulphate of copper ( $\text{CuSO}_4, \text{H}_2\text{O}, 4\text{Aq}$ ), be taken as an example :—

Cu equivalent	68.86	=	68.86
S	32.00	=	32.00
O	16.00	$\times 9$	= 144.00
H	1.00	$\times 10$	= 10.00

249.86 = equivalent of the salt.

As	249.86 : 100 :: 68.86 : x	= 25.40 = Copper.
As	249.86 : 100 :: 32.00 : x	= 12.88 = Sulphur.
As	249.86 : 100 :: 144.00 : x	= 57.74 = Oxygen.
As	249.86 : 100 :: 10.00 : x	= 4.01 = Hydrogen.

# RESULTS.

Copper	= 25.40 per cent.
Sulphur	= 12.88 "
Oxygen	= 57.74 "
Hydrogen	= 4.01 "

99.98

327. Rule by which the per-centage of the various Compound  
Constituents of a Chemical Salt may be calculated.

---

- 1st. Calculate the equivalent of the salt.
- 2nd. State by simple proportion, as the equivalent of the salt is to 100, so is the quantity of the compound in the salt, the per centage of which is to be determined, to  $x$ .  
 $x$  = the per centage of the compound in the salt.
- 3rd. Repeat No. 2 statement for as many compounds as there are in the salt.

Let crystallized carbonate of sodium [ $\text{Na}_2\text{CO}_3, 10(\text{H}_2\text{O})$ ] be taken as an example; the per centages of soda, carbonic acid, and water are required to be determined.

$$\begin{array}{l} \text{Sodium} \\ \text{Carbonate} \end{array} \left\{ \begin{array}{l} \text{Na}_2 = 23 \times 2 = 46 \\ \text{C} = 12 = 12 \\ \text{O}_{13} = 16 \times 13 = 208 \\ \text{H}_{20} = 1 \times 20 = 20 \end{array} \right.$$

---

286 = equivalent of the salt.

---

$$\begin{array}{l} \text{As } 286 : 100 :: 62 : x = 21.67 = \text{Soda } (\text{Na}_2\text{O}) \\ \text{As } 286 : 100 :: 44 : x = 15.38 = \text{Carbonic Acid } (\text{CO}_2) \\ \text{As } 286 : 100 :: 180 : x = 62.93 = \text{Water } (\text{H}_2\text{O}) \end{array}$$

RESULTS.

$$\begin{array}{l} \text{Soda } (\text{Na}_2\text{O}) = 21.67 \\ \text{Carbonic Acid } (\text{CO}_2) = 15.38 \\ \text{Water } (\text{H}_2\text{O}) = 62.93 \end{array}$$

---

99.98

---



328. Rule by which the empirical formulæ of a compound may be determined, the per-centage composition by weight being given.

1st. Divide the percentage composition respectively by the equivalent weights of each element in the compound.

2nd. Take the lowest of the quotients as unity (one equivalent), and divide the other quotients by it. This will give the relative proportion in which the elements exist.

EXAMPLE.—The percentage composition of a salt was found to be:—

Copper	=	25.40
Sulphur	=	12.88
Oxygen	=	57.74
Hydrogen	=	4.01
		<hr/>
		99.98
		<hr/>

$$25.40 \div 63.56 = .4 = \text{Copper.}$$

$$12.88 \div 32.00 = .4 = \text{Sulphur.}$$

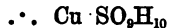
$$57.74 \div 16.00 = 3.6 = \text{Oxygen.}$$

$$4.01 \div 1.00 = 4.01 = \text{Hydrogen.}$$

The lowest quotient is .4, and is therefore taken as unity; then

$$3.6 \div .4 = 9 = \text{Oxygen.}$$

$$4.01 \div .4 = 10 = \text{Hydrogen.}$$



A glance at these numbers shows that the formulæ of the compound is  $\text{CuSO}_4 \cdot 5(\text{H}_2\text{O})$ , which is the formulæ of crystallized sulphate of copper.

## 329. WEIGHTS AND MEASURES.

---

FRENCH WEIGHTS.

One Kilogramme	=	2·68098 pounds troy.
“ “	=	2·20606 “ avoirdupois.
“ “	=	15484 grains.
“ Cubic Centimetre	=	0·0610 cubic inch.
“ Litre	=	61·0271 cubic inches.

## ENGLISH WEIGHTS.

One pound, Avoirdupois	=	7000 grains.
“ “ Troy	=	5760 “
“ ounce Avoirdupois	=	480 “
“ “ Troy	=	487·5 “
“ drachm Apothecaries	=	60 “
“ “ Avoirdupois	=	27·844 “

The Imperial gallon contains of water at 60 deg. 70,000 grains.

The pint ..... 8,750 “

The fluid ounce ..... 487·5 “

The pint = 84·66 cubic inches.

20 fluid ounces = 1 pint.

8 pints = 1 gallon.

---

## 330.—Weights and Measures.

Grammes.	Grains.	Decigrammes.	Grains.
1 =	15.4346	1 =	1.5434
2 =	30.8692	2 =	3.0869
3 =	46.3038	3 =	4.6304
4 =	61.7384	4 =	6.1738
5 =	77.1730	5 =	7.7173
6 =	92.6076	6 =	9.2607
7 =	108.0422	7 =	10.8042
8 =	123.4768	8 =	12.3476
9 =	138.9114	9 =	13.8911
10 =	154.3460	10 =	15.4346

Centigrammes.	Grains.	Milligrammes.	Grains.
1 =	.1543	1 =	.0154
2 =	.3086	2 =	.0308
3 =	.4630	3 =	.0463
4 =	.6173	4 =	.0617
5 =	.7717	5 =	.0771
6 =	.9260	6 =	.0926
7 =	1.0804	7 =	.1080
8 =	1.2347	8 =	.1234
9 =	1.3891	9 =	.1389
10 =	1.5434	10 =	.1543

Metres.	Inches.	Centimetres.	Inches.
1 =	39.37	1 =	.3937
2 =	78.74	2 =	.7874
3 =	118.11	3 =	1.1811
4 =	157.48	4 =	1.5748
5 =	196.85	5 =	1.9685
6 =	236.22	6 =	2.3622
7 =	275.59	7 =	2.7559
8 =	314.96	8 =	3.1496
9 =	354.33	9 =	3.5433
10 =	393.70	10 =	3.9370

331. TABLE for the Conversion of Degrees of Centigrade  
Thermometer into Degrees of Fahrenheit's Scale.

Cent.	Fahr.	Cent.	Fahr.	Cent.	Fahr.	Cent.	Fahr.	Cent.	Fahr.	Cent.	Fahr.	Cent.	Fahr.
Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.
—30	—22·0	0	32·0	30	86·0	60	140·0	90	194·0	120	248·0		
—29	—20·2	+1	33·8	31	87·8	61	141·8	91	195·8	121	249·8		
—28	—18·4	2	35·6	32	89·6	62	143·6	92	197·6	122	251·6		
—27	—16·6	3	37·4	33	91·4	63	145·4	93	199·4	123	253·4		
—26	—14·8	4	39·2	34	93·2	64	147·2	94	201·2	124	255·2		
—25	—13·0	5	41·0	35	95·0	65	149·0	95	203·0	125	257·0		
—24	—11·2	6	42·8	36	96·8	66	150·8	96	204·8	126	258·8		
—23	—9·4	7	44·6	37	98·6	67	152·6	97	206·6	127	260·6		
—22	—7·6	8	46·4	38	100·4	68	154·4	98	208·4	128	262·4		
—21	—5·8	9	48·2	39	102·2	69	156·2	99	210·2	129	264·2		
—20	—4·0	10	50·0	40	104·0	70	158·0	100	212·0	130	266·0		
—19	—2·2	11	51·8	41	105·8	71	159·8	101	213·8	131	267·8		
—18	—0·4	12	53·6	42	107·6	72	161·6	102	215·6	132	269·6		
—17	+1·4	13	55·4	43	109·4	73	163·4	103	217·4	133	271·4		
—16	3·2	14	57·2	44	111·2	74	165·2	104	219·2	134	273·2		
—15	5·0	15	59·0	45	113·0	75	167·0	105	221·0	135	275·0		
—14	6·8	16	60·8	46	114·8	76	168·8	106	222·8	136	276·8		
—13	8·6	17	62·6	47	116·6	77	170·6	107	224·6	137	278·6		
—12	10·4	18	64·4	48	118·4	78	172·4	108	226·4	138	280·4		
—11	12·2	19	66·2	49	120·2	79	174·2	109	228·2	139	282·2		
—10	14·0	20	68·0	50	122·0	80	176·0	110	230·0	140	284·0		
—9	15·8	21	69·8	51	123·8	81	177·8	111	231·8	141	285·8		
—8	17·6	22	71·6	52	125·6	82	179·6	112	233·6	142	287·6		
—7	19·4	23	73·4	53	127·4	83	181·4	113	235·4	143	289·4		
—6	21·2	24	75·2	54	129·2	84	183·2	114	237·2	144	291·2		
—5	23·0	25	77·0	55	131·0	85	185·0	115	239·0	145	293·0		
—4	24·8	26	78·8	56	132·8	86	186·8	116	240·8	146	294·8		
—3	26·6	27	80·6	57	134·6	87	188·6	117	242·6	147	296·6		
—2	28·4	28	82·4	58	136·4	88	190·4	118	244·4	148	298·4		
—1	30·2	29	84·2	59	138·2	89	192·2	119	246·2	149	300·2		



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